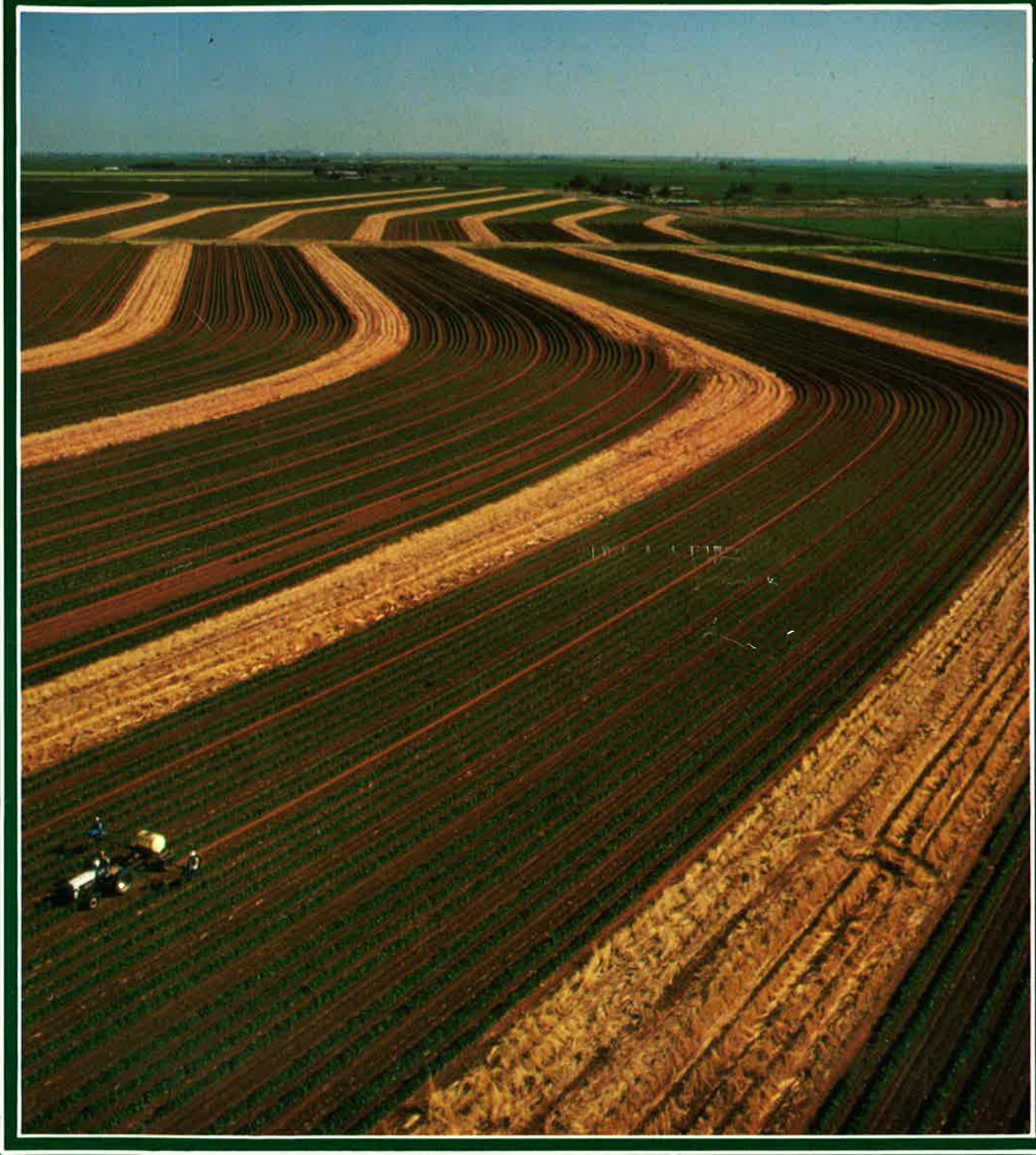
1990

Resource Notes-Academic Year 1989-90

Resource Notes

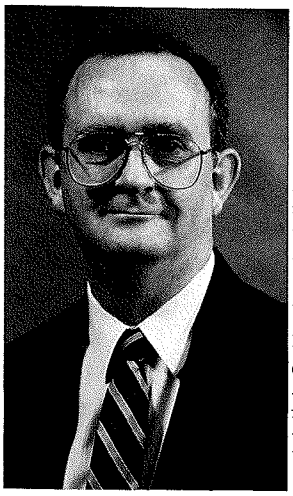
Vol. IV

1989-1990 Academic Year



The annual report of the Conservation and Survey Division

Earth Day initiatives need adequate data



Recently, we celebrated the 20th anniversary of Earth Day, an important event, especially in terms of public awareness of environmental processes and problems. It is to the credit of my predecessors, George Condra, Eugene Reed and Vincent Dreeszen, that the Conservation and Survey Division has been involved in collection and unbiased interpretation of environmental data for almost 70 years. The importance of this service is highlighted in several articles in this volume.

Some of the earlier water-data collection efforts in Nebraska began about 1930 when the Conservation and Survey Division, in cooperation with the U.S. Geological Survey and several state agencies, initiated the test-hole drilling program. This has resulted in more than 4,400 test holes drilled to date. And for each of these test holes, samples and well logs are available at the CSD office in Lincoln. But much more drilling still is needed, especially in the western Sand Hills and Panhandle. This program has provided valuable contributions to the state's knowledge of water levels and aquifer characteristics and should be allowed to continue (if funding can be found).

In recent years we have become aware of nonpoint-source pollution of groundwater, caused principally by use of agricultural chemicals. Recent compilation of water-quality data by Mary Exner Spalding points out that there are a number of problem areas in the state, especially along the central Platte Valley. One response to this problem is the designation of special protection areas (SPAs). The newly developed SPA action-plan manual, prepared by CSD and others, will provide guidance to the natural resources districts in the development of SPA action plans.

Many people are unaware of the great storehouses of rock samples and cores that are stored and available for study at the Conservation and Survey Division. These include samples from the test-hole drilling program, petroleum wells and surface outcrops. Users of these data include consultants, local, state and federal agencies and industry. While it is probably not possible to measure the resultant economic impacts, they certainly are considerable.

Automation of data and the use of geographic information systems (GISs) in the analysis of such automated data is a major goal of the Conservation and Survey Division. This automation will take time from qualified professionals, but will result in an automated database that will be available for future natural-resource stewardship.

We know there are some other important problems that need to be addressed, including abandoned and active waste-disposal sites, groundwater-surface water interactions, and layering of contaminants in aquifers. There will no doubt be many problems in the future that we cannot foresee. However, the continuation of basic geologic, hydrogeologic, soils and other data collection, coupled with data automation and GIS, will enable us to address these problems as they occur.

Perry B. Wigley, Director
Conservation and Survey Division

A funny thing happened on the way to press . . .

Editor's note: A funny thing happened in the course of soliciting a commentary piece from Verlon K. "Tony" Vrana, formerly executive director of the planning division of the Nebraska Natural Resources Commission, now the executive vice-president of the Soil and Water Conservation Society, headquartered in Ankeny, Iowa. Resource Notes asked Tony to do an article reflecting on the significance to the professional conservationist of the 20th anniversary of Earth Day. He sent it in, and it was edited. The edited version so pleased Tony that he showed it to someone who showed it to the Des Moines Register. The Register thought highly enough of it to run it as the lead piece on the opinion-editorial page on June 14.

The paper was, of course, completely gracious about our reprinting the story. We thank the Des Moines Register for their permission to reprint and for adding audience and prestige to the article.

Resource Notes

Vol. IV **1989-1990 Academic Year**

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Resource Notes is an annual publication of the Conservation and Survey Division of the Institute of Agriculture and Natural Resources, 113 Nebraska Hall, University of Nebraska–Lincoln, 68588-0517. It is distributed free to all interested in earth science. To receive it, write to the address above. The Conservation and Survey Division is the agency designated by statute to investigate and interpret the geologically related natural resources of the state, to make available to the public the results of these investigations, and to assist in the development and conservation of these resources. The Conservation and Survey Division provides information and educational programs to all people without regard to race, color, national origin, sex or handicap.

On the front cover: *In the recent past contour stripcropping, terraces and conservation tillage methods that leave crop residue on the surface have been considered state-of-the-art conservation practices. Research has generally supported the contention that such systems require no more than normal amounts of agricultural chemicals and conserve soil and water. However, the very practices that hold water (and soil) in place on the field, mitigating nonpoint-source pollution of surface water, may lead to greater infiltration rates, carrying greater concentrations of nonpoint-source contaminants into groundwater. One alternative has been to reduce chemical inputs. Such adjustments are possible through accurate soil testing, a greater reliance on biological means of increasing soil fertility and biological and mechanical control of weeds and pests.* USDA Soil Conservation Service photo.

On the back cover: *"Relay" cropping of soybeans into wheat residue is designed to control erosion, conserve moisture, crowd out weeds and fix nitrogen in the soil.* Photo by Warren Sahs, IANR.

Reflections on the 20th anniversary of Earth Day: Now what?

by Verlon K. "Tony" Vrana
Executive Vice-President
Soil and Water Conservation Society

-Commentary-

The degree of success achieved in any endeavor is often determined more by the standard of measurement than the actual results of the activity. But by what standard do we judge the new (or renewed) environmental awareness expressed in the various events that surrounded the 20th anniversary of Earth Day in April? We might say: by the progress made toward sustainable development 10, 20 or 50 years hence. But what does that mean, if anything, now?

Considering the benefits of events such as Earth Day in the context of the total conservation movement, it would be easy for soil and water or other conservation professionals to pass them off as trivial. Perhaps some do. If so, it may say more about them than about those becoming newly aware. Now that we have gained this widespread interest in conservation, the environment and ecology, from whatever source, the challenge is to determine what can be done with it.

Some Earth Day vows may have been more transitory than New Year's resolutions. To others it may have been an awakening of concern and a stimulation for further study. And, to others still, the current convergence of special environmental events may renew, reconfirm, validate and build on an already existing commitment.

While professional conservationists may recognize the latter group as those with whom we have typically dealt, it is important to realize that they didn't get to the upper rungs of the ladder overnight.

This is the real benefit of events like Earth Day, Arbor Day, Soil and Water Stewardship Week, National Wildlife Week and their ilk [all of which took place by some proclamation or another during the last of April and the beginning of May]. Inevitably, they will mean different things to different people. We can't expect everyone to have a "conversion experience," yet we can expect to see movement up the hierarchy of public understanding.

This increased level of public understanding, for example, has already had its effects on congressional action. The federal government has been supportive of conservation practices, yet it wasn't until the 1985 Food Security Act that environmental provisions were required as a condition for producers to receive other agricultural benefits. A strengthening of these provisions is being considered for the 1990 farm bill. This would not have occurred had it not been for the public support of such action. [This public support is particularly important in the natural resource arena, where a producer's short-term economic goals may dictate one course of action and long-term societal benefits quite another - *(from the original version)*- Ed.]

We see many other examples of increased public awareness taking shape in recycling, in packaging and in consumer preferences in general. The public is supportive of a more sustainable ecosystem. While we tend to look to government for leadership, it is often of the "cow-catcher" variety, where politicians seek to determine which way the train of public opinion is headed and then get out ahead by riding the cow-catcher while waving the flag.

Whether or not events such as Earth Day are successful is again dependent upon the standards we set. Setting especially high standards immediately for sweeping action and lasting changes may be self-defeating. What honoring the 20th anniversary of Earth Day has done is bring environmental awareness in from the fringes of public discourse to the mainstream. Whatever cacaphony occurs from too many voices speaking too loudly all at once is probably a fair price to pay in the long run for the legitimacy and urgency now accorded earth science issues. Aldo Leopold said that in pursuit of the higher goals such as Truth, Justice, and Conservation, we will never achieve perfection (or complete success) but only make progress in our striving.

What honoring the 20th anniversary of Earth Day has done is bring environmental awareness in from the fringes of public discourse to the mainstream.

—Vrana

We must recognize that commitment to conservation must burn in the hearts and minds of the "resource caretakers" if our natural resources are to be sustained. The increased public awareness has served to make the circle of caretakers wider and more inclusive, and yet will not, at least over the long haul, compromise the depth of that commitment.

If the Earth Day activities and rhetoric are to be believed, are to be more than last year's soil erosion, then this dedication is no longer the special province of professionals. We will always look to those in research, regulation or planning for timely, accurate information. But this new commitment, if it means anything, now must belong to individuals and industries, to private sector and public, to small, ad hoc groups and huge bureaucracies. This kind of widespread commitment is the capstone; it can lead to the ultimate success. But not if we expect to be led only by an elite "priesthood."

Conservation is everybody's business. When it becomes so, then we will not destroy anything we cannot create, nor create anything we can't destroy.

Tony Vrana was formerly executive director of the planning division of the Nebraska Natural Resources Commission.

Reprinted courtesy of the Des Moines Register

Groundwater 'contaminated to varying degrees'

One-quarter of wells in Bazile Triangle exceed federal nitrate-nitrogen limits

Twenty-five percent of the water samples in a cooperative study of groundwater quality in northeastern Nebraska had nitrate-nitrogen contamination greater than the 10 parts per million maximum contaminant level allowed by federal law.

The highest value in the irrigation-well sampling was 25 parts per million (ppm), while 45 percent had values that ranged from 5 to 10 ppm, with the majority exceeding 7 ppm, according to the University of Nebraska-Lincoln study. The U.S. Environmental Protection Agency (EPA) has set limits of 10 ppm for nitrate-nitrogen in drinking water.

This indicates that groundwater has probably been contaminated to varying degrees, depending on the geology of the water-bearing unit, topography, direction of groundwater flow and distance from over-fertilized fields, feedlots or septic systems, said Dave Gosselin, project coordinator and research hydrogeologist with the UNL Conservation and Survey Division (CSD).

All indications are that the source of groundwater contamination is most likely related to fertilizer practices. This is based on a strong correlation between nitrate-nitrogen and chlorine, which comes from potash used in starter fertilizers, Gosselin said.

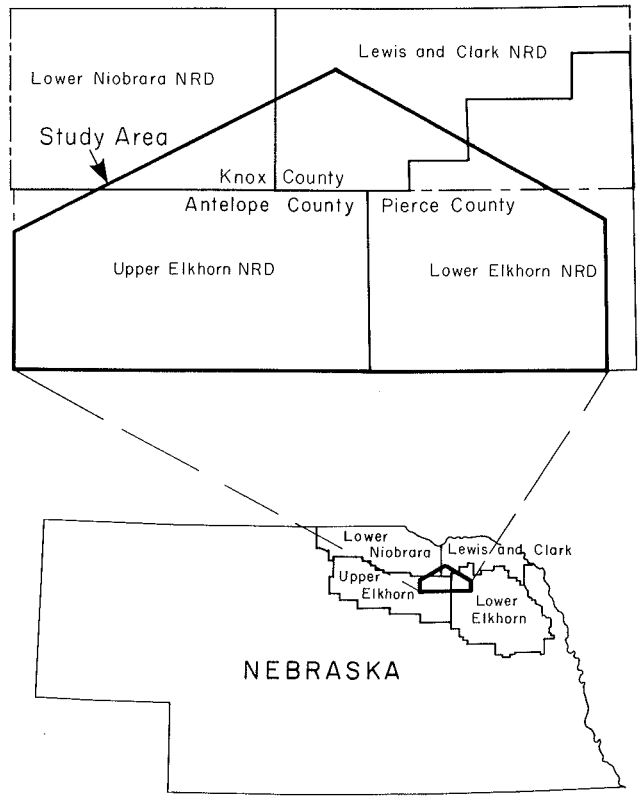
Eight domestic wells and 117 irrigation wells were sampled from July 24 to Aug. 8, 1989, in an area that included northern Antelope, northern Pierce and southern Knox counties.

The majority of samples with nitrate-nitrogen values greater than 10 ppm occur near local and regional drainage divides that have slight to moderate slopes. These are the dominant net-recharge areas, Gosselin said. In these areas, water has a greater tendency to percolate into the soil and transport contaminants to the groundwater.

The research, The Bazile Triangle Groundwater Quality Study, was a cooperative effort involving the Upper Elkhorn, Lower Elkhorn, Lower Niobrara and Lewis and Clark natural resources districts, the Nebraska Department of Environmental Control (NDEC) and CSD.

The project was supported by a $9,000 grant from EPA that was administered by NDEC. The study was to begin assessing the nature, extent and magnitude of nitrate-nitrogen contamination in the groundwater of northeastern Nebraska. These initial findings are the subject of an open-file report available for study at CSD.

All indications are that the source of groundwater contamination is most likely related to fertilizer practices. This is based on a strong correlation between nitrate-nitrogen and chlorine, which comes from potash used in starter fertilizers, Gosselin said.



Location of Bazile Triangle study area

The hydrogeologic framework of the study area is divided into three water-bearing units, he said, the Ogallala, the Plio-Pleistocene and the combined Ogallala-Plio-Pleistocene.

"The Ogallala and Plio-Pleistocene sand and gravel have not been affected by nitrate-nitrogen contamination to the same extent. The Plio-Pleistocene unit appears to have the highest degree of contamination. The Ogallala, on the other hand, is relatively uncontaminated. And where it does show high nitrate-nitrogen values, the Plio-Pleistocene sand and gravel deposits are in direct contact with it. This implies the contamination is probably coming from these overlying sand and gravel deposits," he explained.

"The relationship between the presence of contamination and the presence of sand and gravel indicates that the contamination is not in the Ogallala and is being derived from the sand and gravel," he added.

Seventy-two percent of the wells drawing water from the Plio-Pleistocene unit have less than 10 ppm nitrate-nitrogen, and only 13 percent exceed 15 ppm. In water from the Ogallala, 70 percent of the values are less than 10 ppm, with only one exceeding 15 ppm. In water from the combined unit, samples contained less than 10 ppm in 76 percent of the cases, with 18 percent exceeding 15 ppm, the study said.

To protect the susceptible areas, they must be identified, and this can only be done by acquiring a more detailed knowledge of the hydrogeologic system, Gosselin said.

"The results of this study indicate that groundwater in this area has been contaminated to varying degrees. More work is required to evaluate short-term and seasonal variations in contaminant concentrations. Future study should also determine the depth and degree to which contamination has affected the different water-bearing units before any remedy can be planned," he said.

"A significant step toward reducing future contamination would be for each landowner to re-evaluate fertilizer and irrigation practices to reduce the potential of contamination as much as possible," Gosselin said.

Five-year statewide survey shows increase in nitrate contamination

20 percent of wells exceed federal limits for nitrates

Nitrate-nitrogen levels exceeded federal health regulations in 20 percent of Nebraska wells sampled during a five-year period, according to a University of Nebraska-Lincoln report on pesticides and nitrates in Nebraska groundwater published this spring.

Atrazine, the most commonly used herbicide in the state, was detected in very low concentrations in more than 13 percent of the wells sampled, said Mary Exner (Spalding), chemist with the UNL Conservation and Survey Division, and Roy F. Spalding, associate director of the NU Water Center, authors of "Occurrence of Pesticides and Nitrate in Nebraska's Ground Water." The majority of the wells with detectable atrazine—78 percent—had levels of 1 part per billion or less. Researchers did not know if atrazine levels are increasing or stabilizing.

Their other conclusions were:

—Point-source contamination, particularly from nitrates, occurs most frequently in eastern Nebraska. Often this is due to poor well siting, particularly near infrequently used or abandoned barnyards, and is augmented by poorly constructed wells in the glacial till region. Concentrations above 50 parts per million (ppm) are not unusual. The U.S. Environmental Protection Agency has established a maximum contaminant level (MCL) of 10 ppm for nitrate-nitrogen.

—Fifty-one percent of the elevated nitrate-nitrogen concentrations and 70 percent of the atrazine concentrations were where groundwater is highly vulnerable to contamination. Areas considered highly vulnerable were characterized by monoculture irrigated corn on well- to excessively well-drained soils with less than 50 feet to groundwater. The central Platte River valley typifies these areas. In that area, the source of the nitrate is leachates from commercial fertilizers.

(Leachates from manure applied to irrigated corn in areas highly vulnerable to contamination can also cause nonpoint nitrate contamination. This has occurred west of Sidney, where manure from a local feedlot is used to fertilize irrigated corn fields.)

—Concentrations of nitrate in irrigated corn-producing areas are increasing, based on comparisons between this and previous surveys. In areas highly vulnerable to contamination, both the concentrations and the extent of the contamination are increasing.

—The high frequency of atrazine contamination in areas with nonpoint-source nitrate contamination suggests that much of the atrazine is also from nonpoint sources.

Data for the report was provided by the U.S. Geological Survey, the Nebraska Department of Health and Department of Environmental Control, natural resources districts, Lincoln-Lancaster County Health Department and from other studies within the UNL Institute of Agriculture and Natural Resources. Data on nitrates were from the 1984-1988 period. The pesticide data were from all available information before Jan. 1, 1989.

The report said that the concentrations of nitrates exceeded federal standards in 29 percent of the irrigation wells and 17.5 percent of the domestic wells tested from 1984 to 1988. Nitrate levels were measured in 5,826 wells.

Atrazine, the most frequently used pesticide, was detected, usually in very small amounts, in 13.4 percent of the 2,260 wells tested for atrazine. Only 1 percent of the wells with atrazine exceeded the 3 parts per billion MCL.

Exner and Spalding recommended the following steps to reverse the increases in nonpoint contaminant concentrations:

—Suspend statewide groundwater monitoring for five years and redirect the effort to vadose (unsaturated) zone sampling and groundwater sampling in areas of suspected nonpoint contamination.

—Determine the half-life of atrazine and other detected triazine herbicides in the unsaturated zone below the crop rooting zone and in the aquifer.

—Develop monitoring schemes to assess the impact of groundwater protection measures on contaminant concentrations below the crop rooting zone.

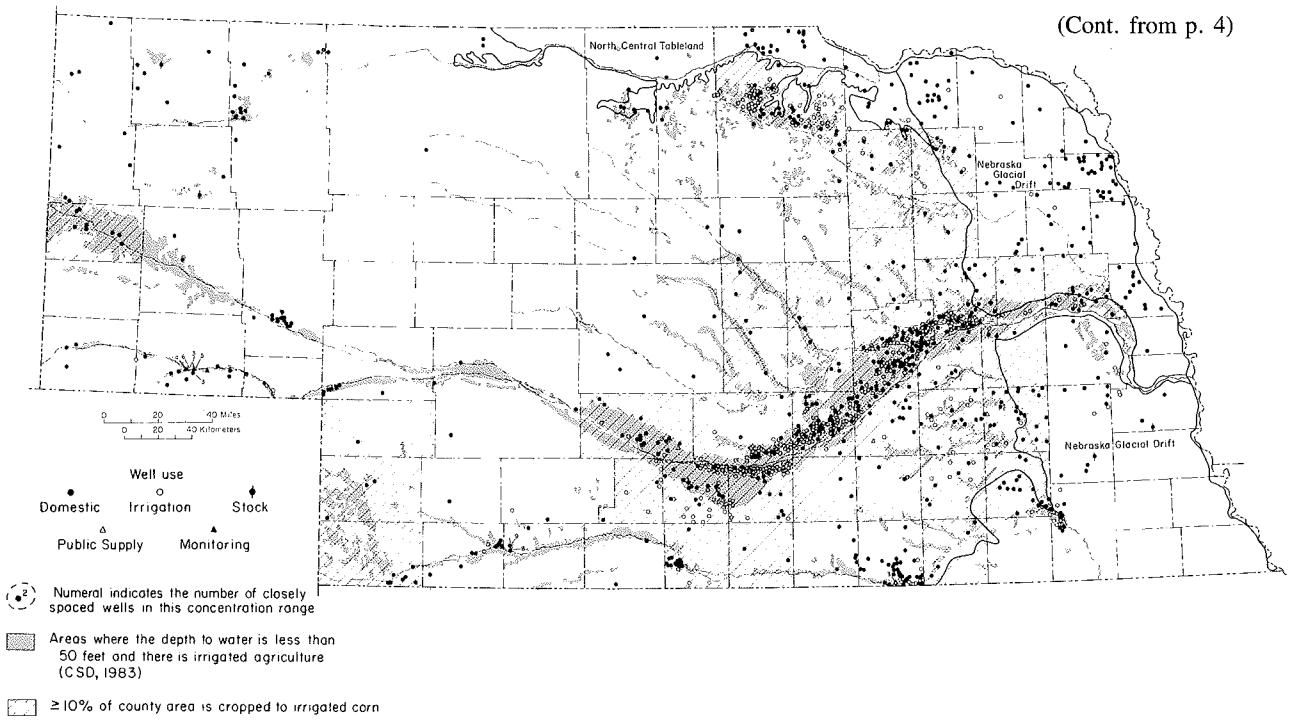
—Develop nitrogen- and water-management practices more effective in combating nonpoint contamination.

—Determine the vertical movement of nonpoint agricultural chemicals in the dryland farming areas of eastern Nebraska.

—Investigate the feasibility of enhancing denitrification in nitrate-contaminated groundwater.

The publication is available for $5 plus $1.50 for shipping from the NU Water Center, 103 Natural Resources Hall, University of Nebraska-Lincoln, 68588-0844.

(Cont. from p. 4)



Distribution of nitrate-nitrogen concentrations at or above 10 ppm

SPA manuals a lesson in planning, agency cooperation

Developing two groundwater-management handbooks compared

by Charles Flowerday
Editor, CSD

Any law that requires the development of a plan is "the tip of the iceberg."

So said the leader of a project to develop a manual helping the state's natural resources districts (NRDs) write action plans if a special groundwater-quality protection area is designated in a given NRD. The state's NRDs have been charged with writing these plans, which would outline steps to combat nonpoint-source contamination, if such a designation occurs. The Nebraska Department of Environmental Control (NDEC) has to approve the plans.

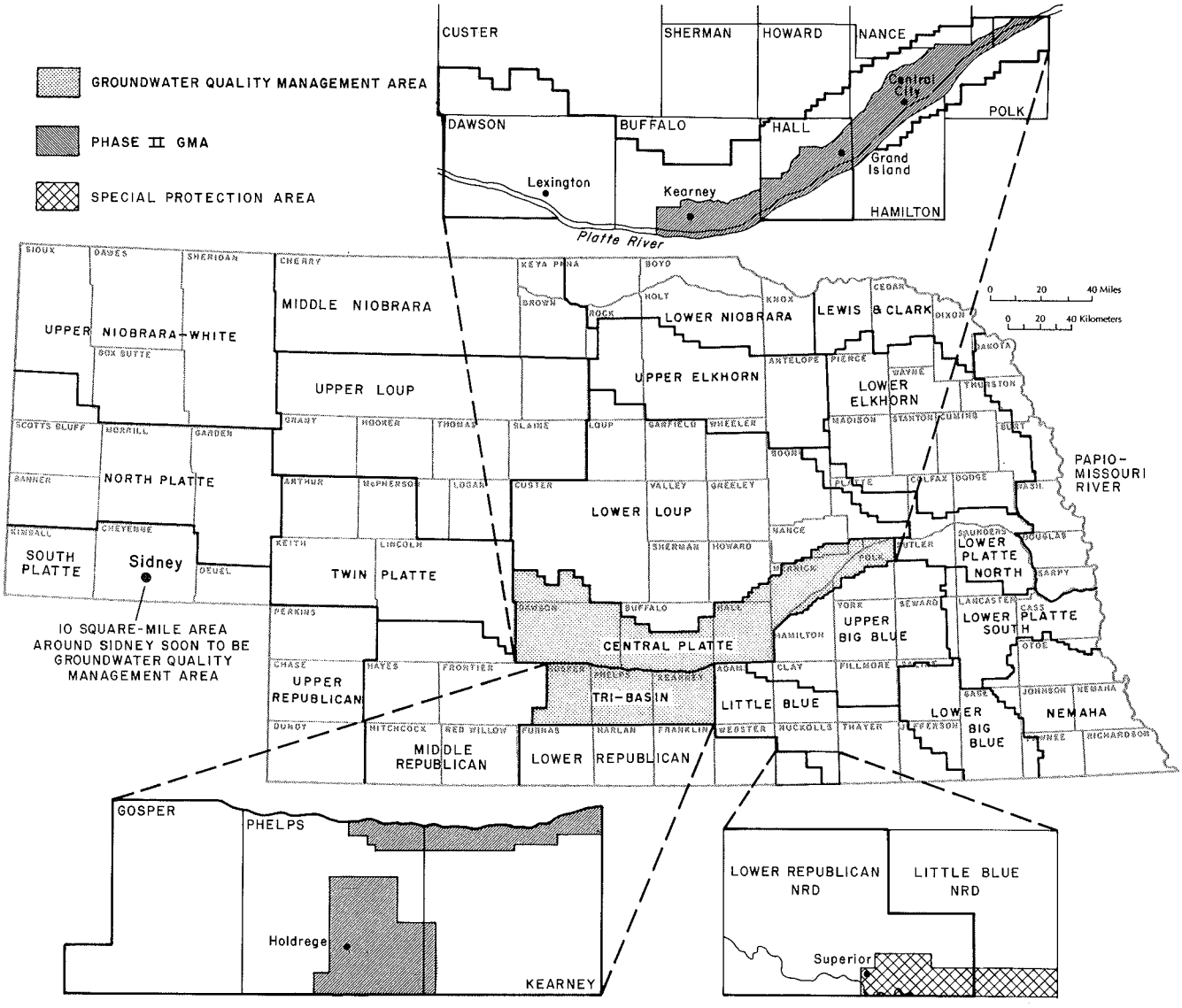
"Usually little thought about how the plan should be developed is embodied in the legislation, so that someone developing a manual about how to do a plan has to do an awful lot of interpretation," said Bob Kuzelka, water resources planner with the University of Nebraska-Lincoln Conservation and Survey Division (CSD) and assistant director of the NU Water Center.

Kuzelka compared his experiences designing two groundwater-management planning manuals aimed at helping the NRDs better manage groundwater. First, he and former CSD hydrogeologist, Gene Murray, designed one to help the NRDs write groundwater-management plans as required by the Nebraska State Legislature. Planning is systematic problem-solving to solution, he explained. And the project, a request from the Nebraska Association of Resources Districts (NARD), became an example of inadequate coordination among agencies during the planning process.

"Usually little thought about how the plan should be developed is embodied in the legislation, so that someone developing a manual about how to do a plan has to do an awful lot of interpretation."

—Kuzelka

The plans, which had to be submitted to the state Department of Water Resources (DWR) by Jan. 1, 1986, were largely concerned with managing the quantity of groundwater. And while the authors did get comments from DWR—



Location of special protection area and groundwater quality management areas. Shaded areas within Central Platte and Tri-Basin natural resources districts are in Phase II, which involves certain restrictions on agricultural chemicals. In addition, NDEC recommended that the Tri-Basin NRD annex a 41-square-mile area to the Phase II section of its groundwater management area. Mostly in southwestern Kearney County, this area extends north of Hildreth to Axtell and west of Axtell.

which had to approve the plans—they did not seek a final sign-off from this agency regarding the manual's contents. One consequence of this was that only about half the management plans received approval the first time. Four still have yet to be approved.

In addition, the language of the law requiring this plan was rather vague, Kuzelka said. It said DWR had to approve the plan, but it didn't say the NRD had to adopt it, or if it was turned down, what the consequences were.

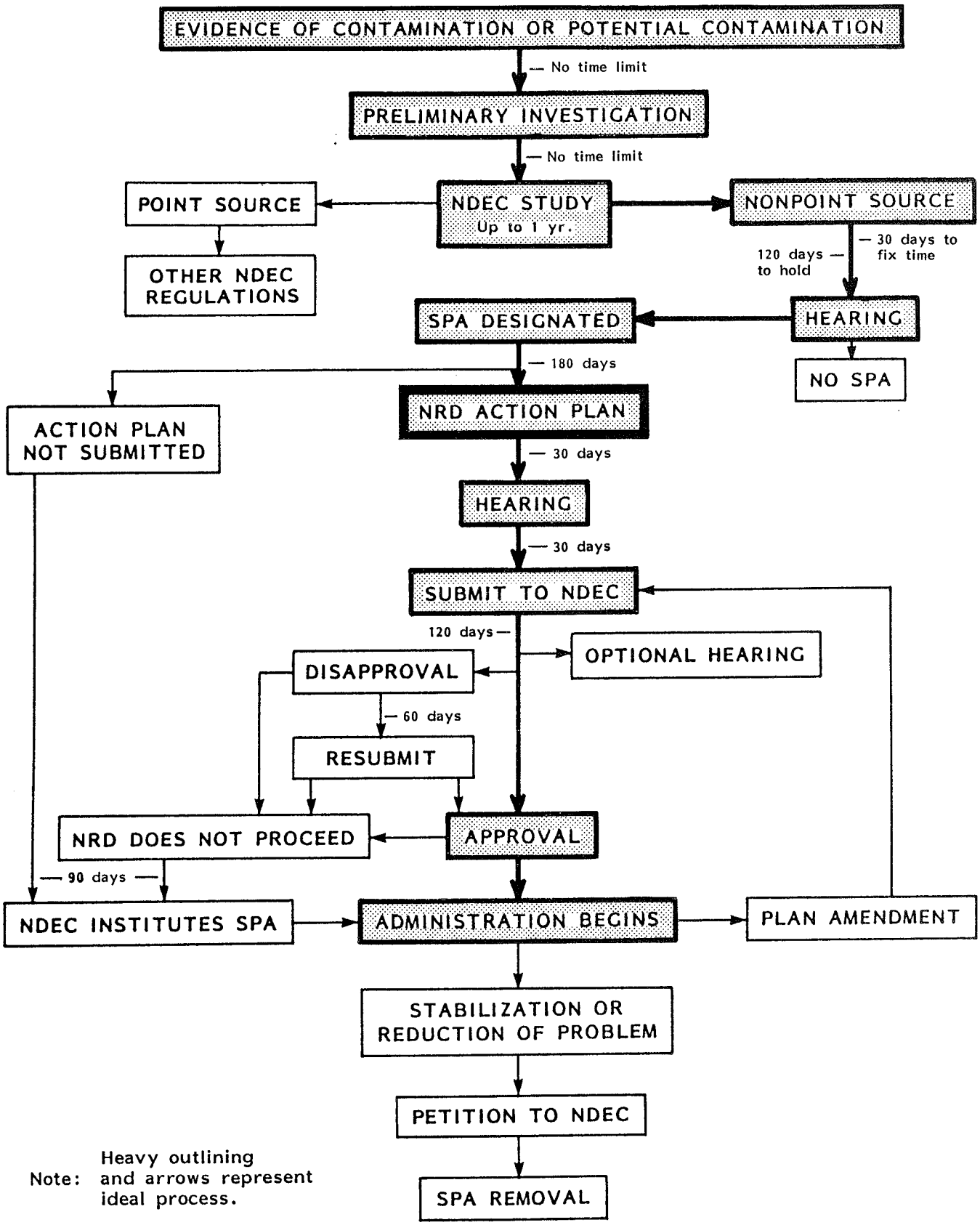
Special protection area (SPA) legislation, by contrast, was aimed specifically at nonpoint-source pollution from agricultural chemicals, Kuzelka said, and addressed planning and procedures a little more explicitly.

In 1986, the legislature authorized NDEC to designate SPAs to mitigate against or prevent pollution by nonpoint-source contamination. The first area was designated in February near Superior and Hardy in Nuckolls County. The area includes parts of the Lower Republican and Little Blue NRDs. After the official designation on Feb. 13, the two NRDs have 180 days to prepare an action plan to combat the nitrate contamination that triggered the SPA.

Another contrast was that one of Kuzelka's main objectives in designing "A Manual on the Preparation of Special Groundwater Protection Area Action Plans" was to come up with a document that NDEC, the regulatory agency, could support. He also wanted to ensure the maximum cooperation and planning by other key institutions, such as the NRDs, NARD and the Cooperative Extension Service, he said.

Such coordination was necessary because a law requiring a plan does not necessarily produce planning, his most significant observation from both experiences, he said. In the absence of a law that sets down details of the planning process, an approach planners would favor, the best alternative is thorough coordination among the key participants in the plan, he said.

Kuzelka also moderated a training session for NRD staff on the use of the manual in April at Kearney. And after the NRDs have had a chance to use the manual for a while, he wants to survey them about its usefulness and analyze the



Flow chart of special protection area process

results, he said.

The SPA action plan manual, a contract report prepared by the division for NDEC and the NARD, was written by Kuzelka, David Aiken, UNL water and agricultural law specialist, Mark Burbach of the NU Water Center and Wanda Schroeder, a private environmental consultant. In addition to NDEC, technical reviewers included UNL specialists in water chemistry, groundwater, irrigation, best management practices (BMPs), tillage and environmental programs, as well some from the state departments of health and agriculture.

The manual was originally intended as a "cookbook," said Dick Ehrman, unit supervisor for the Ground Water Section of the Water-Quality Division of NDEC. But it grew beyond that.

"The document has evolved," he said.

It is now nearly a comprehensive planning document for the SPA process. And, not surprisingly, the type and amount of information needed in the manual was the subject of some negotiation, he said.

"An NRD that would be involved in doing an SPA action plan would still have to do a heck of a lot of work. This is only the bare bones of what's needed. First, the specifics of any plan are going to have to be tailored to the area so it's going to take a lot of detailed work."

—Kuzelka

The main point of discussion between the authors of the manual and NDEC was what more than the strictest legal stipulations it should contain, Ehrman said. In developing an action plan, any NRD needs to gather a great deal of scientific and public information, he added.

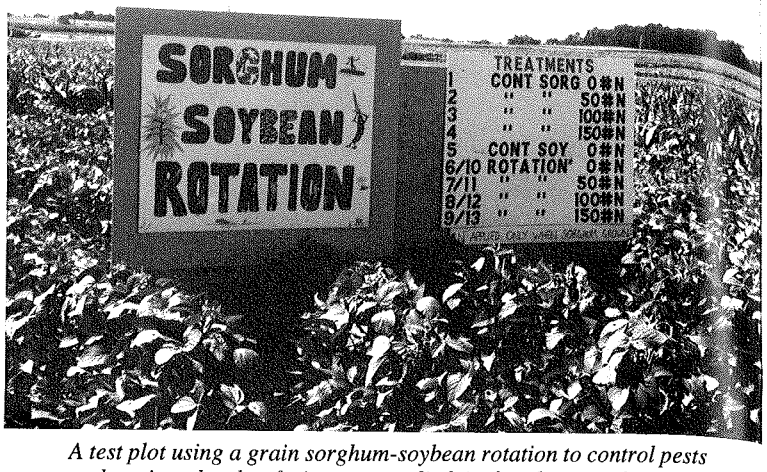
NDEC was a little more conservative than the UNL authors in its estimate of how much information was necessary and what options were available. As a regulatory agency, it was interested in minimizing subjectiveness. But overall, developing the manual was a good process, he said.

Aiken said he thought the discussion about the problems with the legislation stemmed from a misunderstanding of the intent of the law. The legislation was very broad, he said, allowing an SPA where there is an existing problem or where there is likely to be one.

"The law's intent is more preventive than people realize. That's the way the legislature wrote it," Aiken said, outlining the opinions that governed much of his comments during the writing of the manual.

Comments as candid as Aiken's from all the key people and institutions were crucial to the negotiations process, Kuzelka said. Another example of encouraging maximum cooperation among key institutions was a recommendation that, if an SPA request by any party is anticipated within an NRD, representatives of that NRD begin meeting with NDEC even before a formal request is made.

"An NRD that would be involved in doing an SPA action plan would still have to do a heck of a lot of work. This is only the bare bones of what's needed," Kuzelka said. "First, the specifics of any plan are going to have to be tailored to the area so it's going to take a lot of detailed work."



Warren Sahs, IANR

A test plot using a grain sorghum-soybean rotation to control pests and various levels of nitrogen applied (only when sorghum was grown).

Secondly, he said, although it was originally assumed that during a 1-year study, NDEC would evaluate the need for an SPA and outline the pollution sources needing attention, determining the causes of nonpoint-source contamination has not been as easy for NDEC as the drafters of the law might have thought.

"So, much of the early parts of the plan will have to deal with better defining causes, which is not included in the legislation at all," Kuzelka said.

Aiken said most problems with causes stem from an overly conservative approach to the law. The law exists to control agricultural chemicals contaminating groundwater by having the NRDs get farmers in a certain area to use BMPs, he said.

Responding to the issue of clearly establishing causes, Ehrman explained that his agency is concerned about the possibility of a lawsuit if a farmer whose use of pesticides or fertilizers was restricted chose to challenge the designation that included his property. This could hamper the early stages of the implementation of the program, he said.

Kuzelka said that the second most significant issue that emerged in compiling the manual was that SPAs are not the only solution to nonpoint groundwater-quality problems. Groundwater-management areas (GMAs) for water quality, which embody no state regulations, also involve education about BMPs and leave the regulatory administration in the hands of the NRD, are an option. He cited the Central Platte NRD and, more recently, the Tri-Basin NRD, as examples. An area near Sidney in the South Platte NRD also will soon be a GMA for water quality.

In addition, alternatives to designating SPAs could include county and community zoning and land-use planning authorities or intergovernmental cooperation between municipalities and NRDs, Kuzelka said.

As far as the NRDs were concerned, the chapter on alternatives to SPAs was one of the most useful parts of the manual, said Gordon Kissel, executive director of the NARD. Much of the other information is public record, but the options to SPAs are important to the NRDs because designating an SPA does not include as much local control.

"We're delighted with it," Kissel said of the manual.

The SPA manual provides a uniform focus and foundation

for every district to do an SPA action plan, he added, but the NARD was concerned that the NRD boards saw a menu of choices possible in dealing with nonpoint-source problems.

Kissel also lauded the cooperative effort in developing the manual. While Nebraska has a tradition of strong local government, it sometimes falls short at the state level. State agencies can strengthen their position by cooperating to help provide a general focus for local entities such as NRDs, he said.

Groundwater management areas may be an option

Special protection areas help NRDs cope with nonpoint pollution, but not the only way to go

by Charles Flowerday
Editor, CSD

The best action plan for a special groundwater-quality protection area or groundwater-quality management plan is one that the area's producers buy into, said the geologist in charge of planning for the special protection area program for the Nebraska Department of Environmental Control (NDEC).

"The most acceptable option is to reduce (agricultural) inputs," added Dick Ehrman, unit supervisor for the Ground Water Section of the Water Quality Division of NDEC. "But it's better if it's voluntary," he said.

As unique to Nebraska as the natural resources districts (NRDs) themselves, special protection areas (SPAs) for groundwater quality can be designated by NDEC at the request of any political subdivision. They encourage the state's tradition of NRD control in dealing with nonpoint-source contamination through education and voluntary restraint. However, the NRDs can phase in certain restrictions on agricultural chemicals if needed.

After the designation of an SPA, the NRD has 180 days to develop an action plan to deal with the contamination. If the action plan does not meet with NDEC approval, or if an NRD refuses to administer the SPA, NDEC is charged with running the program.

As many see it, the SPA legislation, passed in 1986, came in response to a general perception that the state and the NRDs were not acting fast enough to deal with nonpoint-source pollution caused by agricultural chemicals. This concern was made manifest by an initiative petition—a referendum that would have placed groundwater-quality protection statutes on the ballot.

The first SPA in the state was designated Feb. 13 along the Kansas border in southern Nuckolls County from just west of Superior to the eastern boundary of the county. The request came from the Lower Republican and Little Blue NRDs. Several wells in the narrow strip of irrigated farmland had nitrate contamination that approached or exceeded the maximum contaminant level (MCL) of 10 parts per million set by the U.S. Environmental Protection Agency (EPA).

Other requests for SPAs by the Lower Big Blue and Lower Platte North NRDs resulted in studies done in 1988 by NDEC that yielded one recommendation of 3 years of further study for an area northwest of Beatrice and another of no designation for an area between the Elkhorn and Platte rivers near Fremont.

In addition, recommendations from 1989 studies recently were made public on two more requests. One was for the eastern part of the Upper Big Blue NRD, including parts of Butler, Seward and Saline counties, and another for an area near Minden that includes parts of Phelps, Kearney, Harlan and Franklin counties. This was a response to a request made jointly by the Tri-Basin and Lower Republican NRDs.

"The most acceptable option is to reduce (agricultural) inputs. But it's better if it's voluntary."

—Ehrman

NDEC recommended the Upper Big Blue NRD sample more wells, do soil coring and run educational programs in the eastern third of the district. A decision on an SPA will be made after the entire NRD is studied. Another recommendation was that the Lower Republican NRD study northwestern Franklin County near Hildreth for three years. This area will be re-evaluated for designation in 1992.

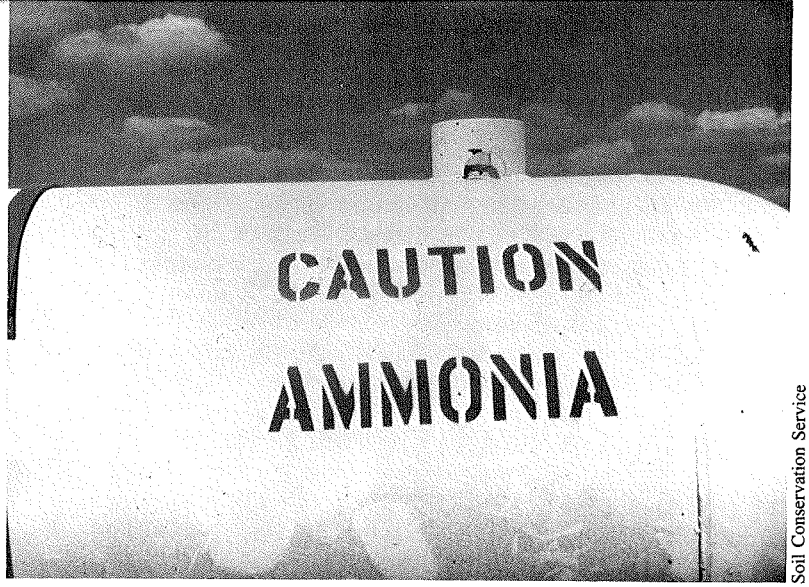
In addition, NDEC recommended that the Tri-Basin NRD annex a 41-square-mile area to the Phase II section of its groundwater management area (GMA). This area extends north of Hildreth to Axtell and west of Axtell. Phase II includes some restrictions on agricultural chemicals.

Studies during 1990 will focus on the central and northern parts of the Upper Big Blue NRD—north of the west fork of the Big Blue River—and on Hitchcock and Red Willow counties. The latter was the result of a request from the Middle Republican NRD.

"The SPA route has been another option that the NRDs could consider if they did not have the resources to do a little up-front characterization (of the problem area). The year-long study period that the SPA program gives to NDEC provides a few more resources and a little broader expertise to actually help NRDs define where their problem areas might be," Ehrman said.

Ironically, he added, while it can provide staff support, NDEC can't raise money specifically for an SPA if the NRD is unwilling to administer the program.

"The amount of funds we have is just about enough to go ahead and maintain the program and do designation stud-



Soil Conservation Service

Chuck Francis, IANR

Chemical inputs such as anhydrous ammonia (left), once relatively cheap, have been applied liberally in traditional farming practices, often with the philosophy, "if some is good, then more must be better." As groundwater and agronomic researchers have documented the increasing hazard of nonpoint contamination from agricultural chemicals, particularly nitrates from commercial fertilizers, other means of fixing nitrogen in the soil have been sought. One such method is to seed a field with a legume cover crop, such as the sweet clover pictured here.

ies and get us that far, but there are some serious questions about whether that amount would be enough to implement an SPA if an NRD couldn't or wouldn't do it," Ehrman said.

More funding would be crucial to administering educational programs, ensuring proper fertilizer management and monitoring groundwater quality, all requirements of the SPA program. In light of this, the creation of an SPA is not a "sacred cow" to NDEC, he added.

"We're not saying the SPA is the only way to address these problems," Ehrman said. "If the (threat of an) SPA program causes enough pain and discomfort that the NRDs adopt groundwater management areas, the problem's being addressed."

"We're not saying the SPA is the only way to address these problems. If the (threat of an) SPA program causes enough pain and discomfort that the NRDs adopt groundwater management areas, the problem's being addressed."

—Ehrman

Ehrman said responses from NRD staff and boards regarding the possible creation of SPAs have generally been one of the following three types:

—Those who have said they don't have the expertise and financial resources for the studies and program and are glad to get help.

—Those who don't want help because they are already tackling nonpoint contamination themselves through GMAs, such as the Central Platte NRD, which is running one of the premier programs in the nation, he said. Another GMA is in the Tri-Basin NRD, and a 10-square-mile area centered in Sidney within the South Platte NRD is about to become one.

—Those who want to wait and see whether they will pursue an SPA or a GMA, depending on the experience of those with SPAs. This attitude characterizes most of the NRDs needing to address nonpoint-source problems, he said.

David Aiken, UNL water and agricultural law specialist, said the SPA program is a national model but its Achilles heel is inadequate funding. The NRDs have received taxing authority at 2 cents per $100 for running an SPA program and can levy 4 1/2 cents per $100 for general NRD activities.

The higher value of irrigated cropland makes the funding potential greater for those areas and probably adequate, especially for areas including municipalities. However, the program still could run into financial trouble with rangeland or dryland designations if the area wasn't big enough, he said.

Because NDEC doesn't have the resources to administer a program all by itself, it wants to work where an NRD is willing to cooperate, rather than waste limited funds. But this is leading to a conservative approach in designating SPAs, Aiken said. The intent of the legislation is more preventive than people realize, he added.

Some NRDs may be waiting to act on nonpoint-source problems to see what happens regarding state administration of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). If the state took over the administration of FIFRA, as all other states in the nation have, and aggressively enforced EPA's new pesticide strategy, then decisions on pesticides would be made at the state level and an SPA becomes largely a fertilizer-management program, Aiken said. During the 1990 legislative session, a bill to have the state take over FIFRA was considered but did not pass.

Overall, regarding policy on agricultural chemicals, he said, Nebraska brings up the tail end on pesticides but is out in front with its fertilizer-management programs.

Gordon Kissel, executive director of the Nebraska Association of Resources Districts, said he believes the management area is the better route for NRDs to take because of the greater control allowed them.

Explaining that the NRDs are now 18 years old and, like any teenager, are still grappling with what they want to be when they "grow up," Kissel added that, in general, the

problem of policing one's neighbors has not prevented NRDs from aggressively addressing nonpoint-source pollution. However, the unpopular role of raising taxes probably has, he said.

"I expect in the future to see many groundwater management areas, not SPAs," Kissel said.

Best management practices should be integrated with total cropping system

Reprinted from "A Manual on the Preparation of Special Protection Area Action Plans":

Best management practices (BMPs) can be implemented to minimize or eliminate many land-use problems, including erosion, runoff, and nonpoint-source pollution. Some BMPs are effective as "stand alone" practices, but many BMPs are more effective when implemented as part of a total land- and crop-management system. This section will discuss BMPs for reducing (or eliminating) nonpoint-source pollution from agricultural chemicals.

1. Buffer Zone Establishment

Buffer zones can be established along any surface-water body (stream, lake, wetland, etc.) or other area that acts as a groundwater-recharge area. The area within the buffer zone functions as an agricultural-chemical dilution or degradation zone to minimize the water-pollution potential of a given chemical. Grassed buffer zones have the added benefit of reducing runoff rates and volumes which may carry pollutants to surface-water bodies.

2. Crop-nutrient Management

Proper crop-nutrient management includes a variety of actions, depending on whether the land is irrigated or dryland. Setting realistic yield goals, utilizing residual soil nutrients and other nutrient sources (for example, manures, legume credits and irrigation water), choosing the proper fertilizer formulation and optimizing the timing and rate of application are all part of a total crop-nutrient management program, regardless of whether land is irrigated or dryland. Additional options for irrigated land include fertigation [fertilizing through irrigation systems] and utilizing the existing water-nutrient load. Crop-nutrient management principles and practices are also applicable for urban lawns, public buildings, cemeteries, golf courses, parks and other recreational areas.

3. Crop Rotations

Crop rotations may significantly reduce the need for pesticides by periodically switching to non-host crops to break insect reproduction and life cycles. Corn rootworms, nematodes and several wheat pests have been effectively reduced or eliminated through crop rotation. Rotations that include legumes or grasses have the added advantage of reducing the need for fertilizers.

4. Integrated Pest Management

An integrated pest management (IPM) system combines a number of practices to control pests (insects, weeds, pathogens, rodents) with minimal use of agricultural chemicals.

The first practice in an IPM system should be choosing pest- and disease-resistant varieties. Planting times may sometimes be adjusted to give the crop a competitive edge over weeds and insects. This adjustment can be done for all varieties, not just resistant ones.

Whenever possible, the user should select the pesticide with the lowest leaching potential. Leaching potential can be further reduced by avoiding pesticide application at times when it is most likely to leach, such as when soils are wet or when the ground has large cracks or macropores in it.

5. Irrigation-water Management

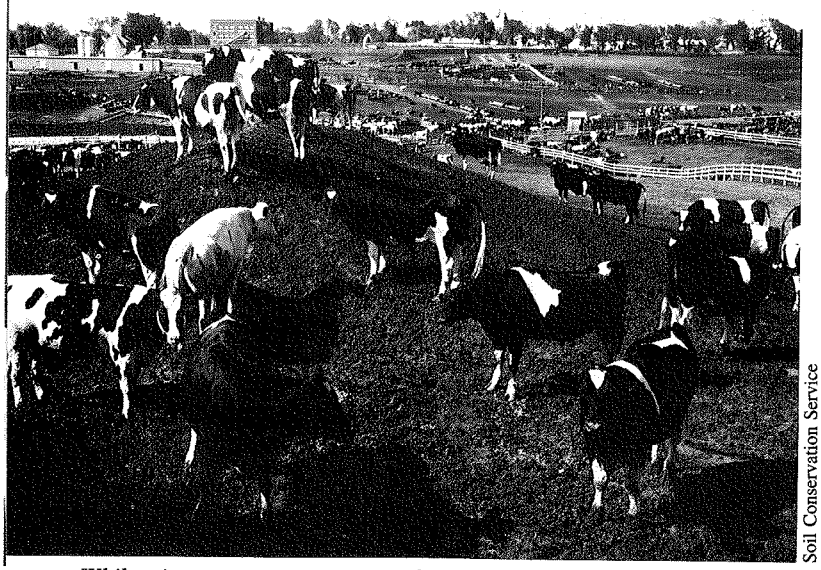
An effective irrigation-water management system will determine how much water a crop needs, will uniformly distribute the correct water amount when needed, and will prevent water runoff from the irrigated field.

6. Limited Chemical Prohibitions

The extent to which chemical applications can be prohibited in an SPA may be limited. The GWMPA [Groundwater Management and Protection Act] does not specifically authorize chemical-use prohibitions, and the "other reasonable requirements" provision may not extend to authorize prohibitions. However, limited chemical prohibition options clearly can be established as part of a BMP authority. Such options might include development of application limitations for pesticides and/or irrigation water, the limiting of the number of acres on which pesticides and/or irrigation water could be applied and recommending a "ban" on pesticide and/or irrigation applications.

Soil Conservation Service

Fish kill in a farm pond in Richardson County caused by chemical runoff from cropland.



Soil Conservation Service

While nitrates are most commonly associated with commerical fertilizers, leachates from manure can also cause nitrate contamination, especially in highly vulnerable areas.

7. Livestock Waste Management

Livestock waste management includes waste handling, storage and disposal. Waste handling should include measures to prevent the accumulation of excess amounts of animal wastes in livestock pens and to keep the wastes from being transported (via runoff) to surface water or from leaching to the groundwater. Waste-storage practices should also address potential surface-water contamination, by including runoff-diversion structures, and potential groundwater leaching, by utilizing impermeable clay liners and concrete or coated-steel structures.

Waste disposal can be environmentally achieved by substituting the waste for commercial nitrogen fertilizers.

8. Tillage Practices

Given current technology, there is little evidence to support the opinion that one tillage system will require more herbicide than another.

Conventional tillage reduces the size and number of macropores, which under some conditions reduces the potential for leaching. The major disadvantage of conventional tillage is the increased potential for soil erosion and the resulting surface-water pollution.

Conservation tillage has the advantage of reducing the potential for soil erosion. In some soil types, it may increase water infiltration rates and reduce runoff. The increased volume of water infiltration, combined with herbicide and insecticide use, may increase the potential for agricultural chemicals to leach to the groundwater in certain soil types and in areas of high water tables.

Contour farming and contour stripcropping reduce soil erosion. Because runoff volumes may be reduced through continuous use of these practices over time, infiltration volumes may be increased.

Level and graded terraces both have the potential for reducing surface-water pollution. Level terraces have the potential to increase pesticide and nitrate leaching by increasing infiltration and, thus, groundwater recharge.

Drought poses special quality problems for municipal wellfields

'Contaminant loading' can result from urban and ag runoff

Though commonly associated with concerns about the amount of water, drought conditions can alter water quality as well. During a drought, increased concentrations of contaminants can be carried in runoff to surface water or can infiltrate to groundwater because contaminants continue to accumulate but little water is available to dilute them.

These observations come from Darryll Pederson, groundwater geologist with the University of Nebraska-Lincoln. In a paper entitled, "Drought Impact on Water Quality: A Wellfield Example," Pederson, hydrogeologist with the Conservation and Survey Division (CSD) and UNL professor of geology, outlined the need for management strategies to deal with water-quality problems posed by drought. Such problems could increase if global warming produces more arid climates in the midsection of the continent.

Basing his observations on literature surveys and research on the Lincoln wellfield near Ashland, which sits adjacent to the lower Platte River, Pederson said these problems can be particularly acute if wellfield aquifers are next to rivers carrying contaminated runoff.

Contaminant concentrations in both urban and agricultural runoff also have more impact on water quality because of the smaller volume of river flow, Pederson explained. Drought can have a dramatic effect on induced recharge because groundwater levels in the wellfield are controlled primarily by the lowered water level in the river and the amount of pumping, which generally increases during a droughty summer.

"The result is that a significant thickness of the aquifer is dewatered," the paper stated. And if a rain comes, the early stages of runoff deliver the highest concentrations of contaminants, Pederson said.

"The result is that a significant thickness of the aquifer is dewatered," the paper stated. And if a rain comes, the early stages of runoff deliver the highest concentrations of contaminants, Pederson said.

"This early water is the bulk of the induced recharge that fills the dewatered zone," he said. "If one runoff event has the potential to recharge a volume of water

equal to a week's pumping, one rainfall event per month could contribute about 25 percent of the water pumped out of the wellfield during a summer drought period. With a more severe drought, the impact would likely be higher," he estimated.

Such a "contaminant-loading" phenomenon is also true of urban runoff, he explained. This is substantiated by research done by a U.S. Geological Survey scientist, Nancy Driver, who documented increased loads of contaminants in urban runoff after extended dry periods.

Agricultural runoff is primarily contaminated by agricultural chemicals, while urban runoff can contain fertilizers and herbicides used in lawn care, spilled oil, heavy metals, oxidizing paint and volatile organic compounds, Pederson said. Data published by the U.S. Environmental Protection Agency (EPA) in 1984 resulting from the National Urban Runoff Program indicated that all 13 metals on EPA's priority pollutant list were detected. Copper, lead and zinc were present in at least 91 percent of the samples, Pederson's paper said.

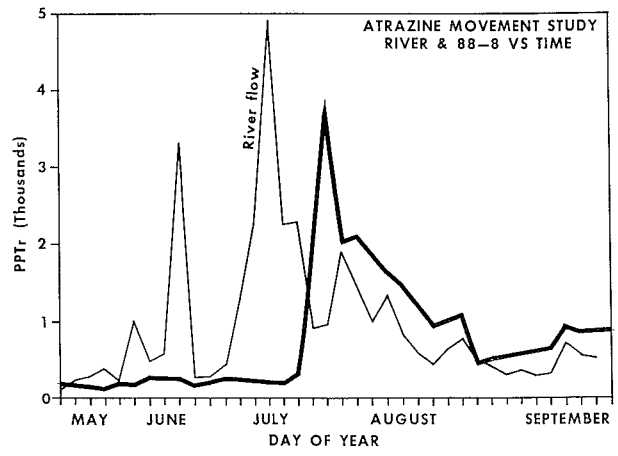
"EPA's water quality criteria and drinking water standards for 'Freshwater Chronic' were exceeded 82 percent of the time by copper, 94 percent by lead, 77 percent by zinc, and 48 percent by cadmium. Sixty-three organic chemicals (also) were reported in urban runoff," the paper stated.

"Because urban areas are concentrated along the nation's rivers, there can be significant change in surface-water quality during drought periods due to runoff," Pederson said. Since the impact would be cumulative, downstream cities withdrawing water for municipal use would have to spend more to treat drinking water during droughts.

In addition, the general drying of the ground during drought causes shrinking, which occurs as settlement along foundations and desiccation cracks in soil, as well as sometimes causing breakage of water pipes, including storm-water drains. All these are ways that water short-circuits the normal soil processes that limit and "filter" infiltrating precipitation.

"If drought management programs restrict uses such as lawn watering, shrinkage effects will be magnified," the paper said.

Using atrazine as a tracer of induced recharge, Pederson and Diana Duncan, a UNL geology graduate student, Jim Carr, UNL professor of chemistry, and T.R. Shephard, a UNL chemistry graduate student, have studied peaks in atrazine concentrations after runoff events as a means of understanding contaminant movement into the wellfield.



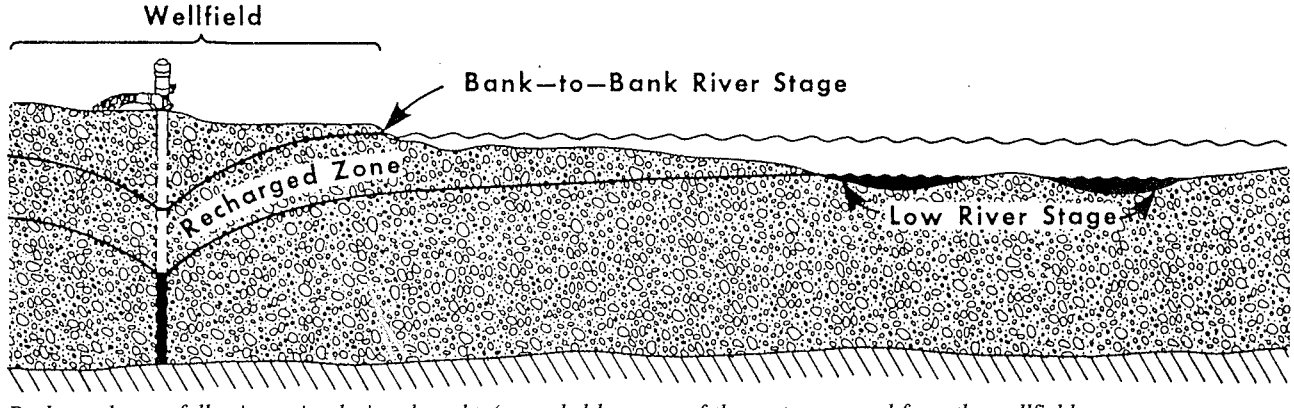
Atrazine concentrations in well water and river flow. Well 88-8 is about 80 yards from the river.

Most of the highest peaks are between 3 and 5 parts per billion (ppb). EPA has recently set limits of 3 ppb as a maximum contaminant level for atrazine.

Atrazine concentrations are high in runoff events and are highest in the initial stages of runoff. And, according to the scientific literature, this is true of many chemicals that run off of farm fields, Pederson says. The group presented their findings in an abstract entitled, "Atrazine as a Tracer of Induced Recharge into an Alluvial Aquifer Along the Platte River near Ashland, Nebraska."

"Distinct peaks of atrazine concentration with time could be detected in the monitoring wells and could be correlated with peaks of atrazine concentration in the river. Peaks could be tracked from the river to production wells," the abstract says.

The herbicide was monitored as it moved from the riverbed to the banks to the wellfield and was traced past a number of wells, Pederson said. The most distant was about 1,000 feet away from the river.



Recharged zone following rain during drought (preceded by low river stage).This zone could amount to about one-quarter of the water pumped from the wellfield.

'Groundwater outcrops' arise from 100 feet deep or more

Role of 'boiling springs' may alter view of stream-aquifer interaction

by Charles Flowerday
Editor, CSD

The discovery of the unique action of a series of conduits along the Dismal River that move water to the surface from considerable depth may change the traditional view of stream-aquifer relationships, said a University of Nebraska-Lincoln groundwater geologist.

These "groundwater outcrops," found along the Dismal in Hooker and Thomas counties and possibly occurring elsewhere, often have been called "boiling springs" because they can appear to bubble. But neither heat nor air pressure creates the effect. Due to the movement of water and sand, this "bubbling" can create a dome of water near the center of the pool.

Once developed, the conduits have a long life and can "short-circuit" groundwater discharge from deeper geologic units, explained Darryll Pederson, research hydrogeologist with the Conservation and Survey Division and UNL professor of geology.

"The fact that you have pin-point sources like that instead of the uniform seepage concept of the past is a significant change in viewing the process of groundwater flow to the stream."

—Pederson

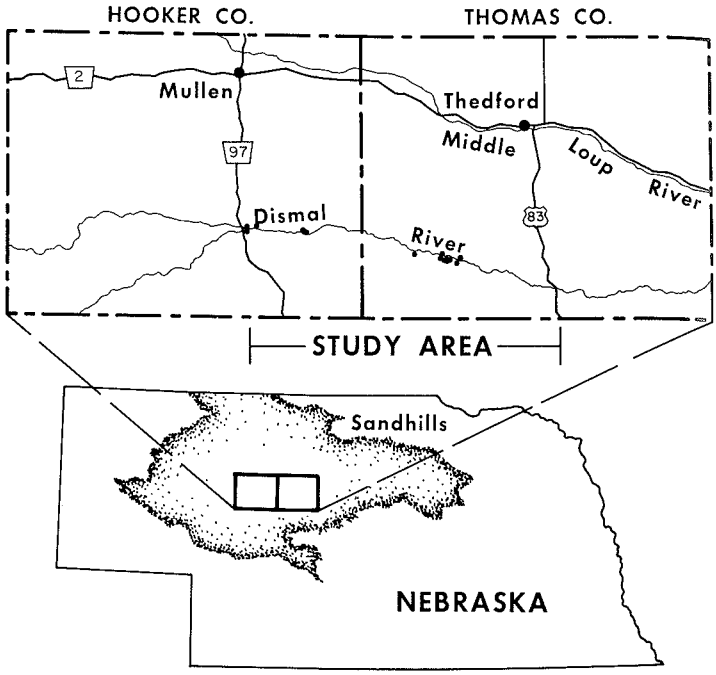
The conduits Pederson has studied have measured as much as 100 feet deep or more and 20 feet in diameter. Flows have been measured as high as 900 gallons a minute. One located in the riverbed yielded an estimated flow rate of many thousands of gallons a minute, he said.

How these conduits function could be very important to the understanding of streamflow, Pederson explained.

"The fact that you have pin-point sources like that instead of the uniform seepage concept of the past is a significant change in viewing the process of groundwater flow to the stream," Pederson said.

"You have an entirely different management concept if conduits are responsible for (a significant amount of) baseflow than if broad, uniform seepage is, as with the past concept. Because if the water's coming from deeper units, it would be possible (with pumping) to draw the head down into the deeper units and significantly affect baseflow to the stream, much more than you would find strictly under unconfined conditions," he added.

Because some springs tend to be clustered near pinchouts of coarse-grained gravels, irrigation development in these areas could have much more of an impact than development elsewhere.



Location of Dismal River conduits ("boiling" springs) study area. Small black dots along the Dismal mark the location of the conduits.

Ann Guhman, a former UNL graduate student in geology, measured the dimensions of the conduits. And Julie Gilbert, another former UNL graduate student in geology, analyzed the water chemistry to identify its sources.

Water discharging from the deeper conduits in the upper reaches of the Dismal has the same chemistry as water from wells screened in the middle and upper Ogallala Group units, Pederson said. Water discharging from springs clustered in the central part of the study area has the same chemistry as water from wells developed in sands and gravels above the Ogallala.

"We've been trying to determine what component of total river flow these boiling springs represent. We've also been interested in why these springs are there and their impact on the development of the river valley. As erosion continues, what would be the impact of boiling springs yet to be uncovered in the evolution of the river valley?" he said.

Are the boiling springs there because the valley is there? Or is the valley there because these conduits have existed in the past and the valley is eroding in preference to these vertical pathways?

In addition, Pederson doesn't think these conduits are unique to the Dismal River valley. In other river systems,

their effect probably has been masked by surface water runoff, he said.

Responding to a poster display on the springs at the 1989 Nebraska Water Conference, a number of ranchers said they had seen similar springs on their property, he said. And not all these were Sand Hills locations, he added.

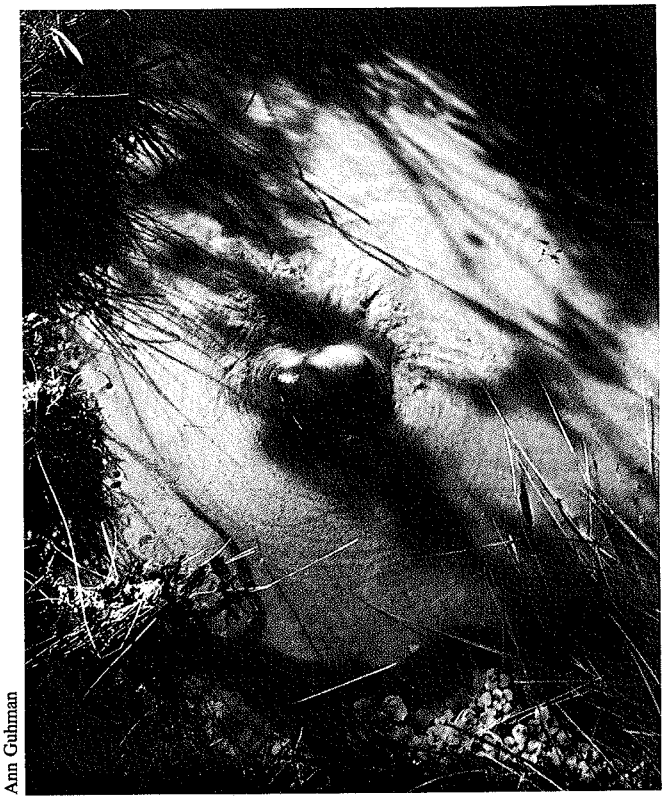
While warning against too much "arm-waving" in relation to the new information about the springs, Pederson said another significant piece of the puzzle is that the springs' flow varies with time. The change in flow doesn't appear to be related to rainfall but to barometric pressure. The same ranchers reporting conduits on their property said they noticed a difference in flow in individual springs depending on whether a storm is coming.

"So I'm sure we're on to something. But we're trying to quantify it," he said.

Lastly, he explained, published flow records indicate many Sand Hills streams seem to act in unison, increasing or decreasing in flow as a group. This phenomenon led to the study of the river systems and, consequently, the springs.

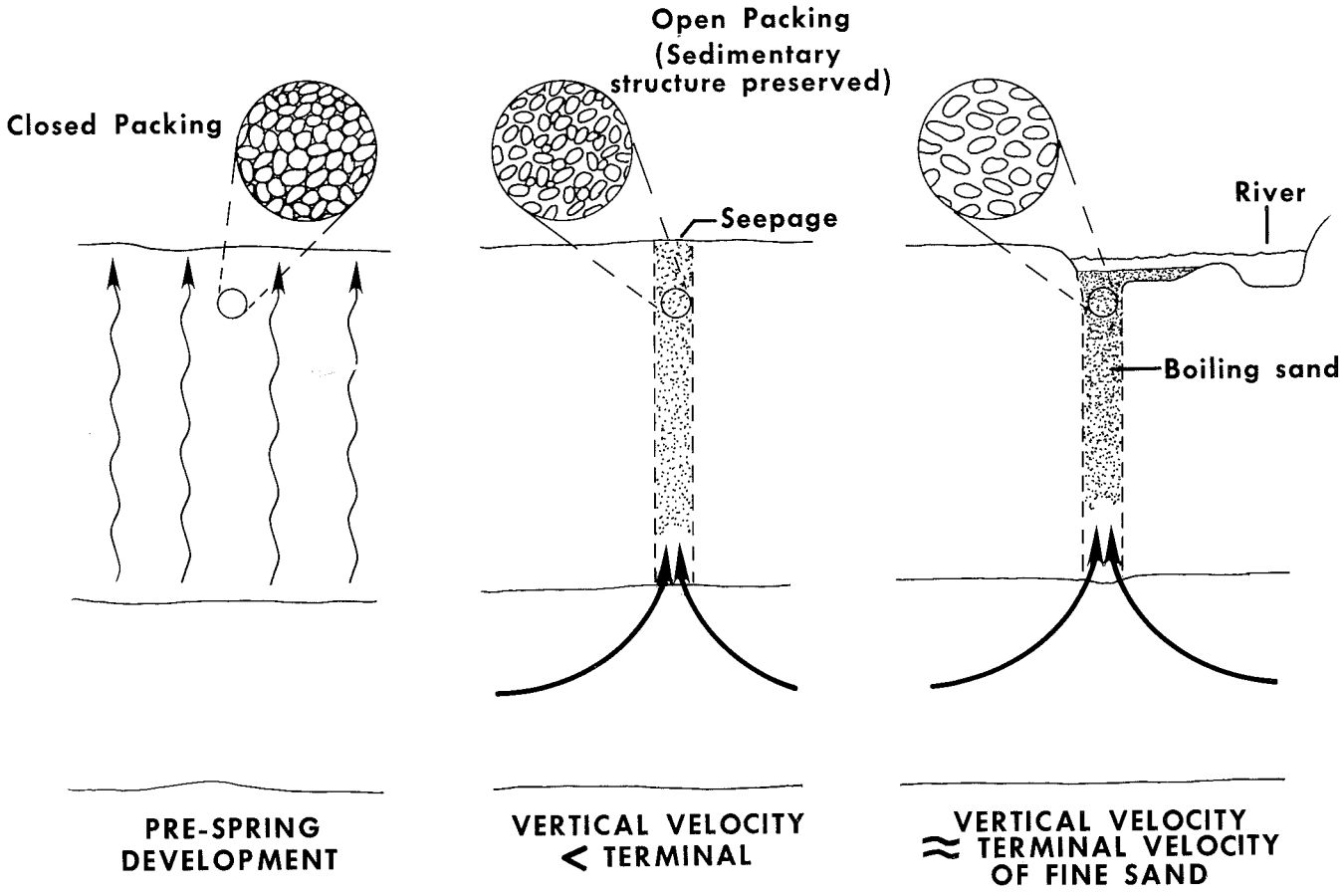
"We were hard-pressed to explain why streams 100 miles apart should have a decrease in flow at the same time," he said.

Sand Hills streams are important because of their relative regularity of flow. If that regularity is interrupted, he said, it is likely to occur during the summer, when water demand is at a peak downstream. Because the flow of the lower Platte River is sustained by the Loup system—into which the Dismal flows and which drains much of the Sand Hills—



Ann Guhman

One of the "boiling" springs along the Dismal River. Note the dome of water and sand in the center.



Idealized cross section showing evolution of typical "boiling" spring

the implications for groundwater management are broad, perhaps affecting downstream diversions for irrigation and municipal use.

If it were just the Dismal, which flows at about 200 cubic feet per second at the gauge south of Thedford, that would be interesting, but less dramatic than what might be the case if the phenomenon is more widespread, Pederson said.

"I do not believe that these conduits are unique to the Dismal. There's no reason why (they) should exist only there," he added.

In memoriam: Maurice Kremer and Morris Skinner

Editor's note: During the past academic year, two renowned contributors to the study and development of Nebraska's natural resources died. They were involved in distinctly different spheres of endeavor, but both left indelible marks on their respective fields. And while Resource Notes has traditionally covered Conservation and Survey activities and research and an occasional story from within the rest of the UNL Institute of Agriculture and Natural Resources, it seemed appropriate to veer from that tradition in honoring these two men. Maurice Kremer, former state senator from Aurora, did as much as any single legislator to bring appreciation for and wise management of Nebraska's natural resources, particularly its water, into the state's laws and collective consciousness. Morris Skinner, world-class vertebrate paleontologist from Ainsworth, left behind nearly a third of the largest collection of North American fossil mammals in the world. The memories of both deserve our deepest respect.

Kremer sponsored 24 bills on water management

'Mr. Water's' successes much more than drops in the bucket

by Brad Rundquist
Editorial Assistant, CSD

Former state Sen. Maurice Kremer once said, "Success without a successor is failure."

And now, a successor is needed to build on Kremer's many successes. He died Feb. 10 at age 82 after a long bout with cancer.

Kremer, of Aurora, was known to his colleagues as "Mr. Water." He sponsored at least 24 bills related to the management of Nebraska's water resources during his 20-year career in the Nebraska State Legislature.

"No one had created a government sub-unit for 100 years, and no one has since."

—Schmit

One of the most important bills created the state's 24, now 23, natural resources districts (NRDs), according to Sen. Loran Schmit of Bellwood, a long-time friend and colleague of Kremer.

"No one had created a government sub-unit for 100 years," Schmit said, "and no one has since."

The districts were developed in 1972—as broadly based local conservation agencies—to monitor, manage, protect and even regulate the use of water and land. Nebraska is the only state in the nation with such a political subdivision.

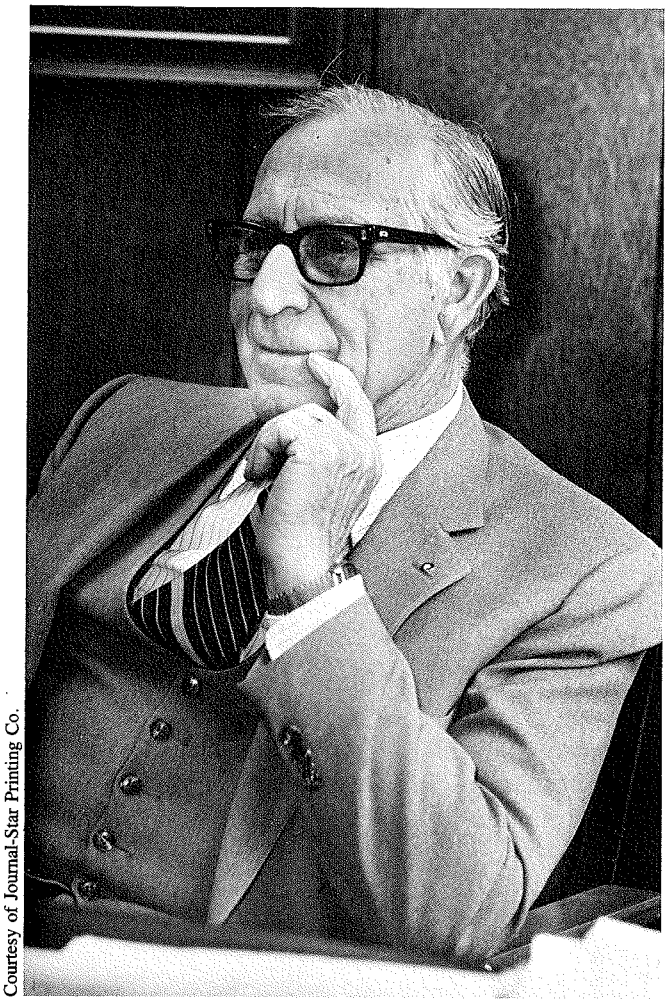
Kremer had a unique vision, Schmit said. He said Kremer credited his ideas to the fact that he lived through the 1920s and 1930s and saw the absolute necessity for irrigation in central and western Nebraska.

"He was around when there wasn't any water, and he was convinced that it (the 1930s drought) would happen again," he said. "He pushed water legislation even when it wasn't popular to do so. His ideas were way ahead of his time."

Kremer once explained, "I grew up in the 1930s, when it didn't rain. Water was a precious commodity, and I dreamt of having a well of my own."

Vince Dreeszen, former director of the University of Nebraska-Lincoln Conservation and Survey Division (CSD), said Kremer was a "staunch defender of irrigation and the wise management of water resources."

Kremer, who represented the 34th district, was one of the first irrigators in Hamilton County. His first well was installed in 1940 south of Aurora. He helped organize the Hamilton County Irrigators Association and later a groundwater conservation district. The district quickly began to measure water levels and employ wise water-management



Courtesy of Journal-Star Printing Co.

Former state Sen. Maurice Kremer

techniques. It has the longest continuous water-level records of any local group in Nebraska.

In the legislature, from 1962 to 1982, Kremer's involvement with water management grew. He chaired the Agriculture Committee for four years and the Public Works Committee for 10 years.

He was key in the passage of the original Groundwater Management Act of 1975, helping establish the state's water planning and review process, the development of groundwater-management guidelines for the NRDs and processes for groundwater control and protection. He also worked to create the UNL Institute of Agriculture and Natural Resources and the state's community college system.

Dreeszen said Kremer relied on CSD to provide scientific background for his bills. It was his main source of information about groundwater. Kremer called on Dreeszen many times, and Eugene Reed, CSD director before him, to testify on water bills.

Dreeszen said he will also remember Kremer as "a fine gentleman and statesman."

Kremer could always tell a story to illustrate a problem and ease tension, he said.

One time, Dreeszen said, he went with Kremer to talk to a group of farmers about groundwater control. Opposition to control almost led to things getting out of hand. But Kremer got up and told a story, using his power of persuasion to keep things in order.

"He had a story for every occasion," Dreeszen said.

Kremer was deeply concerned with children and their education, Dreeszen said. He quit school in the 11th grade to help on the family farm. In 1931, he received a 2-year degree from the College of Agriculture at the University of Nebraska. He would have preferred a four-year degree, he once said, but the depression and drought of the 1930s prevented it.

As a member of the Education Committee, he pushed for education because, Schmit said, "he was concerned that there weren't enough young people to carry on the fight."

Schmit said he will remember Kremer's sense of humor and patience.

"He never lost his patience with colleagues who didn't share his vision," Schmit said. "When he lost a battle, he left his arguments on the floor and would only joke about it."

Schmit said that a few months before Kremer died, he told Schmit to continue working with water resources. Kremer strongly believed that the water running through or resting on or below Nebraska should be used as efficiently as possible, Schmit said.

Kremer once said, "I'm always fearful that in water-plentiful times. . .we don't share water for the dry years, which in Nebraska are historical dating back to the 1800s.

"There must be a system of compromise, as everyone must live with everyone else, and all groups need water. The future of Nebraska lies in uniting diverse water-management options."

Schmit recalled, "He told me that the aquifer had to be protected and regulated, or the state would one day run out of water. It would be interesting to look back 50 years from now and see how the legislation he pushed for affected the state. We will, for sure, be in a better position because of him."

New reprints from Conservation and Survey

The Mineral Industry of Nebraska: *from* 1987 U.S. Bureau of Mines Mineral Yearbook: L. E. Esparza and R. R. Burchett - Free (RS-79)

The Mineral Industry of Nebraska: *from* 1988 U.S. Bureau of Mines Mineral Yearbook: L. E. Esparza and R. R. Burchett - Free (RS-80)

Pesticide Contamination of Ground Water Artificially Recharged by Farmland Runoff: *from* Ground Water Monitoring Review, Winter 1990: M. E. Exner - $1.50 (RS-81)

The View from on High: Micro-based Processing of Satellite Imagery: *from* Computer Graphics World, December 1985: T. McMillan - $.50 (RS-82)

Field Guide to Geology and Hydrology of the Nebraska Sand Hills: *from* G.S. Holden, ed., *Geological Society of America Field Trip Guidebook, 1988;* Professional Contributions, Colorado School of Mines, No. 12: J.B. Swinehart, J.W. Goeke and T.C. Winter - $1.50 (RS-83)

'Last of the great field paleontologists'

Skinner leaves legacy of much-admired teacher, 'huge, well-documented collection'

Charles Flowerday
Editor, CSD

He has been called "one of the last of the great field paleontologists" in the country by a former student who is now a curator of vertebrate paleontology at the University of Nebraska State Museum.

A bone hunter's bone hunter, you might say.

Another former student, Mike Voorhies, now curator and coordinator of vertebrate paleontology at the NU museum, said that when he was a student collector, Morris Skinner, an Ainsworth native, was "an almost mythological figure spoken of in hushed tones." He was the field man with "the magic shovel," who could find more and better fossils than anyone else.

"Morris was a force of nature. He was like a bull bison. I never detected anything but a passionate pursuit of the truth in Morris."
—Voorhies

"Morris was a force of nature. He was like a bull bison," Voorhies said. "I never detected anything but a passionate pursuit of the truth in Morris."

The forces of nature, however, caught up with this bull bison on Dec. 15 when he died in Ainsworth at age 83.

Bob Hunt, the first of Skinner's students mentioned, said that there isn't a student who worked with them who doesn't have fond memories of Morris and his wife Marie, also a paleontological researcher. A grandfatherly figure to graduate students from all over the country, Skinner would hold daily workshops, as well as what he called "Sunday school" for young paleontologists in his tower office overlooking Central Park at the American Museum of Natural History in New York, Voorhies said.

"I think it's safe to say I learned as much from Morris Skinner as from any other teacher," Voorhies added. And in their field work, Nebraska's vertebrate paleontologists carry on his tradition of meticulous stratigraphic and geographic documentation of any fossil find, Hunt said.

The opportunity to learn from someone assembling such a vast, and initially private, collection was an honor afforded only to qualified workers. Hunt did so while studying and teaching at Columbia University, and Voorhies visited after Skinner became excited about some of Voorhies' fossil finds and invited him to New York.

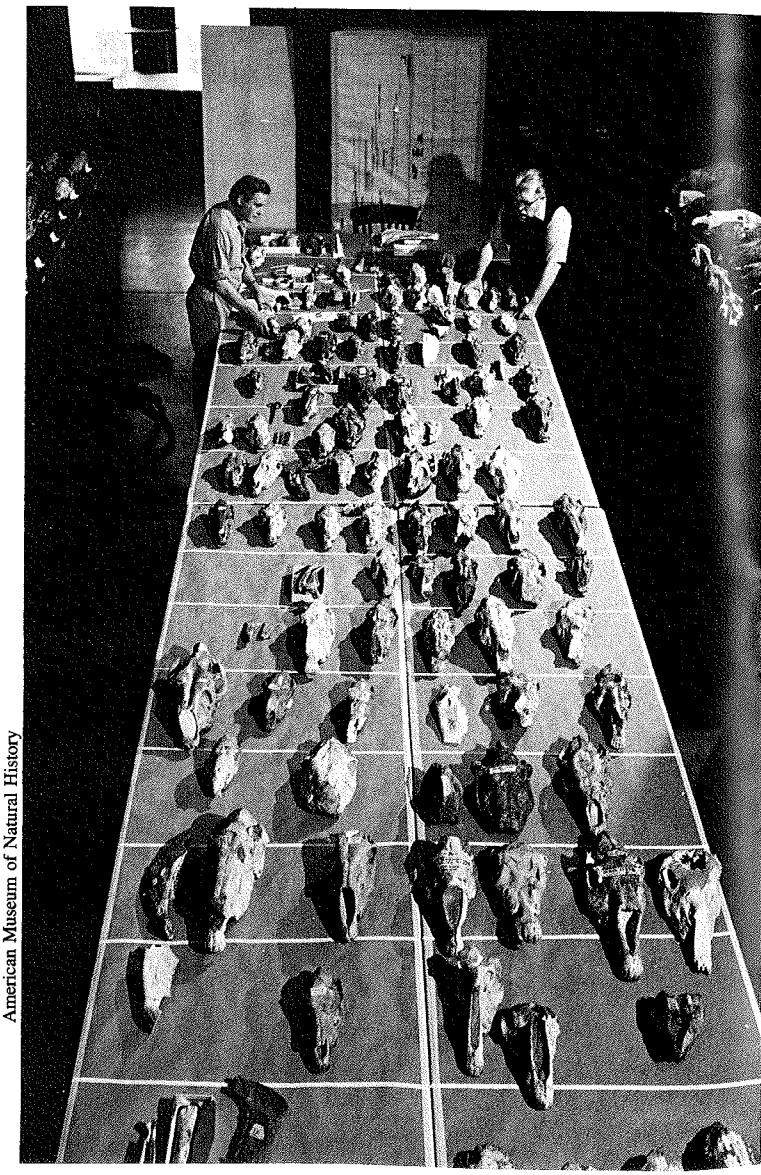
"I ended up staying at Morris' and Marie's apartment for something like 6 weeks and spent about 16 hours a day in the collections," Voorhies said.

For nearly all his adult life Skinner worked for Childs Frick, a wealthy patron of numerous natural-science investigations and trustee of the American Museum of Natural History.

One of Frick's main passions was vertebrate paleontology. In pursuit of his collection, he hired select field men who amassed the largest single assemblage of North American fossil mammals in the world, the largest privately financed collection of fossil mammals in the world and probably the world's largest scientifically documented collection of fossil mammals.

Skinner was Frick Curator Emeritus with the Department of Vertebrate Paleontology at the American Museum of Natural History upon his retirement in 1973. Prior to that, he was Frick Associate Curator. After his retirement from the museum, he was named a research affiliate of the NU State Museum. And in 1978 he received an honorary doctorate from the University of Nebraska-Lincoln.

Morris Skinner (in dark sweater vest) and Ernst Heying, a preparator with the American Museum of Natural History in New York, examine ancient horse skulls at the museum.



American Museum of Natural History

American Museum of Natural History

Morris Skinner and Ernst Heying

Skinner and his assistants contributed about 30 percent of the Frick Collection, said Jim Swinehart, research geologist with the UNL Conservation and Survey Division (CSD), who will write a memorial for the paleontologist for the Geological Society of America Bulletin. And about half of the total collection came from Nebraska, Hunt estimated.

While most paleontologists of his time were zoologically trained, Skinner was relatively unique in that his major was geology. He received his bachelor's degree from NU in 1932. But his career as a bone hunter began before he received any formal training in earth science, sending him to the university to learn more.

Born in Springview Sept. 14, 1906, he graduated from high school in 1925 in Ainsworth, where his family had moved when he was 4 years old. After a stint as a machine shop apprentice in Fort Wayne, Ind.—where he learned much about making machines that would aid his bone hunting—he came back to Ainsworth in spring of 1927 to work as a night attendant at a hydroelectric plant on Plum Creek.

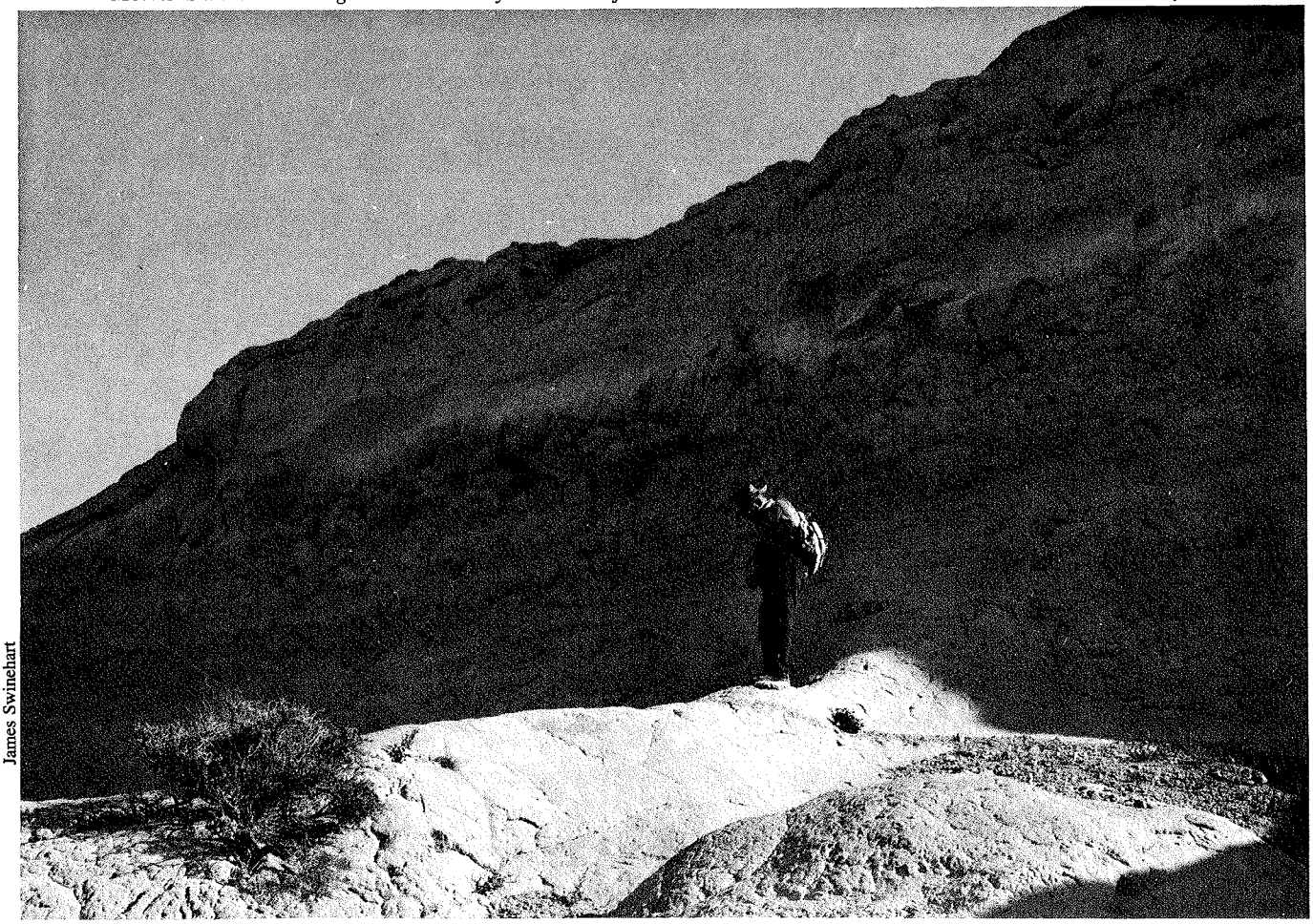
"I had long summer days to prowl the canyons with Jim Quinn, a kindred soul. We found fossils that we couldn't identify, but knowing nothing, we feared nothing and collected them anyway in flour-and-water paste jackets.

"Some we sent to Professor Barbour at the Nebraska State Museum and some found their way to the American Museum of Natural History in New York. That summer we found a deposit that contained an accumulation of long-jawed proboscideans (elephant-like mammals). For this find the Denver Museum in Colorado paid us each $1,000, giving us to understand that they were not 'buying' the collection but merely remunerating us for our summer's work. We didn't care what they called it. We had use for the money," he once wrote in an autobiographical sketch.

"Meanwhile our finds had caught the attention of Childs Frick. . .in New York, and fortunately for me I had summer work from 1927 until 1932 working for Mr. Frick."

The late Jim Quinn eventually became state geologist of Arkansas, one of a number of native Nebraskans associated with Skinner who achieved prominence in geology or paleontology. Others include Voorhies, from Orchard, and the late Ted Galusha of Hay Springs, another of the major Frick field men. Also included in this group is Bob Emry of Ainsworth, who went to work for Skinner as a young man and is now curator of vertebrate paleontology at the Smithsonian Institution in Washington, D.C. Emry will write Skinner's memorial for the journal of the Society of Vertebrate Paleontology, which will honor Skinner at its annual meeting this fall in Lawrence, Kan.

Morris Skinner standing on the Whitney Member of the Brule Formation at Courthouse and Jail Rocks in July 1975.



James Swinehart

In 1933, Frick invited Skinner to the museum, where he prepared and studied fossils. Among other contributions, Skinner helped work out a system of field lists that became the basic catalogs supplying all the geographic and geologic data available.

He became well-known for his painstaking attention to stratigraphic detail, making a stratigraphic section for every quarry and noting to the foot where each specimen was found. This passion for geologic information was virtually unique among paleontologists when he started working. In the early years of the discipline, Hunt said, paleontologists would record only approximate geologic and geographic data for a fossil, not realizing that future studies would require more detailed information.

"The legacy that he has left to the profession of vertebrate paleontology is that huge, well-documented collection, which the rest of us will be benefitting from for a long time. These fossils are going to be there for people to study and argue about for years and years and years."

—Voorhies

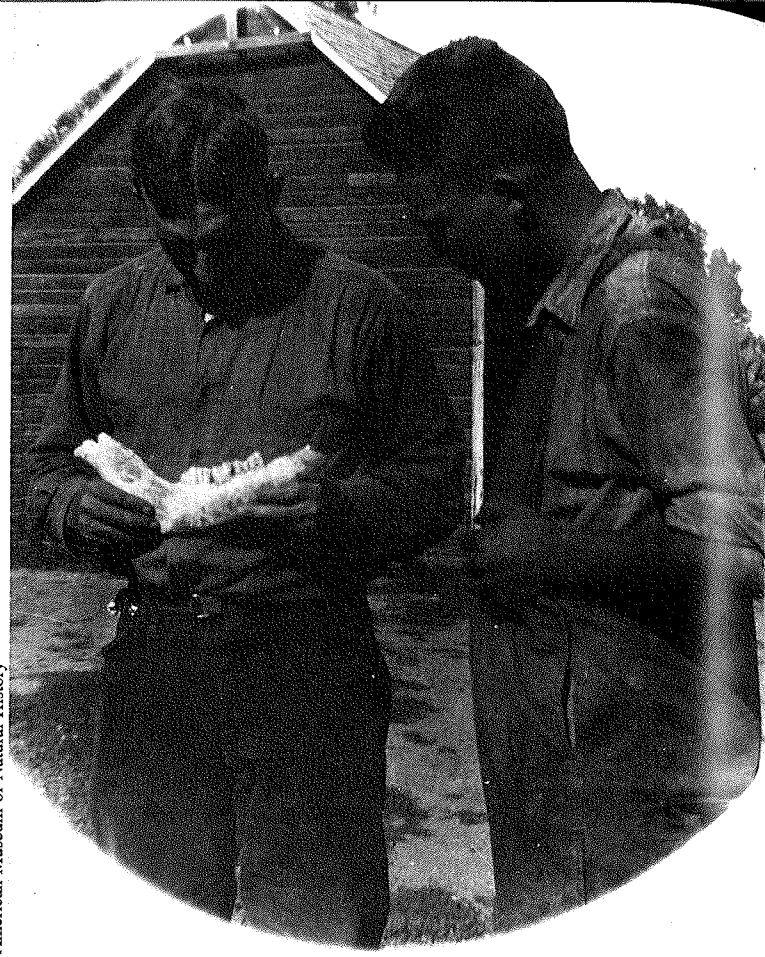
Skinner impressed upon his students this need for exacting documentation. A student once brought him an ancient bear jaw that was considered an extremely rare find, no doubt hoping for lavish praise from his mentor, Hunt said. When Skinner asked him where he had found it, the student pointed away in the distance vaguely, saying, "Over there somewhere."

Skinner then tossed the jaw casually over his shoulder because he couldn't locate it stratigraphically. Although he did finally keep the specimen, he had doubtless made his point about the worth of any find without proper documentation, Hunt explained.

"He really loved to be around the drill rig," Swinehart said of Skinner's passion for stratigraphy. "I don't know of any other paleontologist who spent that much time around a drill rig." He also loved topographic maps, Swinehart said, particularly for their information about drainages and the elevation of various finds. From the time CSD began selling U.S. Geological Survey topographic maps in the 1970s until he died, Skinner had a standing order for any new maps.

As a paleontologist, Skinner's first charge was to collect the large fossil mammals that Frick loved. But he also collected small fossils along the way, microvertebrates such as rodents, snakes and lizards, Voorhies said, or documented their location for future work.

The Frick collection initially was closed to all but Frick's workers, and nearly all publication about its specimens was prohibited during Frick's lifetime. But when he died, the Childs Frick Corp. gave the entire collection to the American Museum of Natural History. Eventually the corporation's assets were transferred to the museum as an endowment for the collection. At this time, extensive publication about the collection became possible, and Skinner began publishing some of the monographic works that Frick believed were appropriate to such an extensive collection.



American Museum of Natural History

Harold Cook (left) and Morris Skinner examine a fossil jaw bone, 1927. Cook was the son of Captain James H. Cook, owner of the Agate Springs Ranch in Sioux County, now Agate Fossils Beds National Monument. James Cook, a rancher and amateur fossil hunter, passed on to his son an interest in bone hunting. Harold became a geologist and in 1910 married another geologist, Eleanor Barbour, daughter of the distinguished Nebraska state geologist, E. H. Barbour.

Frick envisioned studying large populations on a worldwide scale, not just individuals, and in publishing only when widespread collecting had been done. Because of this, Skinner could not be as free with his information as he would have liked until his retirement, Voorhies said. The NU State Museum is currently photocopying Skinner's specimen lists, and it will, with Marie's cooperation, begin doing the same with his field notes, he added.

An expert in the evolution of horses and their dispersal throughout the world, Skinner wanted to do a major definitive study on their evolution, Hunt said, one which will be left to his students to complete. But he did publish extensively on the stratigraphy and biostratigraphy of the areas where he did important work—north-central and northwestern Nebraska and south-central South Dakota—as well as putting out important works on the ancient bison of Alaska and the ancient animal life of Papago Springs Cave in Arizona. Besides horses and bison, his other paleontological interests focused on ancient antelope and rhinos, Voorhies said.

In honor of her husband's life and work, Marie is setting up a scholarship fund for an Ainsworth High School student who wants to study earth science in college.

In addition, Voorhies is planning to honor Skinner's memory at Ash Fall State Park near Royal in Antelope County. Voorhies unearthed a world-class discovery of fossil Miocene-age rhinoceroses there, and construction will begin on the park's structures this summer.

Much of Skinner's legacy, however, will be left to others to interpret and analyze.

"The legacy that he has left to the profession of vertebrate paleontology is that huge, well-documented collection, which the rest of us will be benefitting from for a long time. These fossils are going to be there for people to study and argue about for years and years and years," Voorhies said.

"And Morris realized that. He could have spent his later years taking a few hundred of his fossil horse skulls, or whatever, and describing them in minute detail, but he realized that's something that some future worker could do. But what nobody else could do is document where they came from. This kind of collecting that Morris did, on a large scale, I don't see ever happening again, just for financial reasons. We don't have a Childs Frick among us. Donald Trump is not going to put his billions into paleontology."

New publications from Conservation and Survey

Vegetative Conditions in Nebraska, As Viewed by Satellite, 1988 Growing Season: A. J. Peters and D. H. Greegor, Jr.; color print (eight image-maps; 1:2,500,000) - $2.50 (General Reference Map No. 12)

These image-maps depict National Oceanic and Atmospheric Administration weather satellite data as it would appear on a computer screen through the growing season. One can easily track the progress of the "green wave" moving across the state in late spring and early summer and the "brown wave" that follows in the fall. Drought conditions in the southeastern part of the state are evident. UNL scientists hope to acquire a receiving station for such data in order to continuously monitor drought and other conditions such as wildfires, snow melt and development of storm systems. This and a similar poster for 1987 (a year of mostly normal precipitation) are demonstration projects toward that end.

Oil in Nebraska: by Marvin Carlson; 86 p. - $5.50 (Resource Report No. 11)

This richly illustrated, full-color publication was created to mark the 50th anniversary of the discovery of the first commercial oil well in Nebraska on November 2, 1939. The focus is on historical highlights during the development of the industry. However, a broader understanding of this resource is provided by chapters such as: "Oil: Origin to Reservoir," "Geologic Framework," "Patterns of Production," "The Business of Finding Oil" and a focus on each of the three oil-producing regions of the state, as well as others that emphasize the significance of petroleum resources to our state. The publication is aimed at the general reader and would serve as an excellent resource in schools.

Late Pennsylvanian and Early Permian Cyclic Sedimentation, Paleogeography, Paleoecology, and Biostratigraphy in Kansas and Nebraska: Compiled by Roger K. Pabian and R. F. Diffendal, Jr.; 75 p. - $4 (Guidebook No. 9)

Repetitive sequences of sedimentary rocks are known as cyclothems. The concept has been developed by stratigraphers working in Pennsylvanian and Permian rocks in the North American midcontinent. Classic cyclothemic models developed for Late Pennsylvanian (Missourian) rocks are investigated in east-central and southeastern Kansas, where complete cyclic sequences are observed in the open-marine and algal-mound facies belts. Each of these cyclothems contains nearshore, transgressive, offshore and regressive deposits; these sequences are related to the massing and melting of polar ice caps and glaciers.

Late Pennsylvanian and Early Permian cyclothems in Nebraska contain regressive limestone facies only through deposition of the Howard Cyclothem and regressive limestones do not again fully develop until the deposition of the Early Permian Hughes Creek Cyclothem.

Groundwater Levels in Nebraska, 1988: by Michael J. Ellis and Gregory V. Steele, USGS, and Perry B. Wigley, CSD; 82 p. - $6 (Water Survey Paper No. 66)

This report, the 35th annual report on Nebraska's groundwater levels, summarizes the significant historic changes in water levels and the water-level changes during 1988. These changes are shown through the use of maps and hydrographs. For the readers' convenience, water-level hydrographs are explained at the end of the report. The report also describes the availability of data on water levels, provides information on changes in the water-level measurement program, and summarizes data on the two major causes of water-level changes: precipitation and groundwater use.

Earthquakes in Nebraska: by R. R. Burchett; 20 p. - $4.50 (Educational Circular No. 4a)

This is a revised and expanded, full-color edition of a 1979 publication. The circular is a good introductory earthquake text as it explains the different types of quakes, the ways they are measured and the tools used to measure them. It includes lists and maps depicting the time, magnitude, intensity and location of earthquakes and microearthquakes in Nebraska, as well as six new illustrations.

Nebraska Mineral Operations Review, 1989: by R.R. Burchett and D.A. Eversoll; 15 p. - $1 (Miscellaneous Publication No. 30)

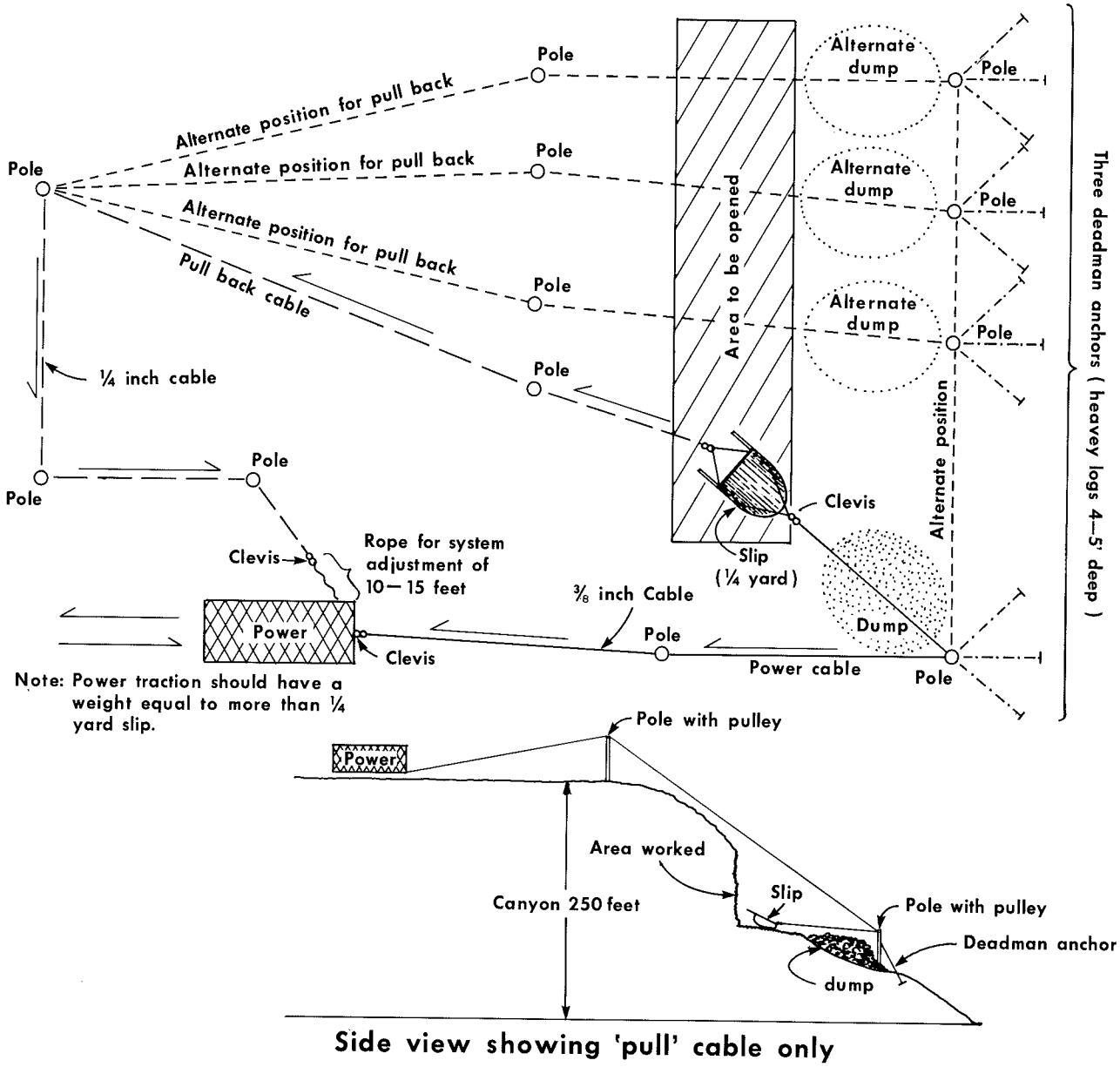
This annual report details all aspects of the Nebraska mining industry in 1989. The publication includes maps depicting the locations of quarries, pits and mines that were active last year and the locations of active oil and gas fields, as well as two tables, one summarizing mining activity by county from 1900 and the other detailing production by county in 1989.

Deep well maps have been updated to 1990 for Banner, Cheyenne, Dundy, Furnas, Harlan, Hitchcock, Kimball, Morrill, Red Willow, Richardson and Scotts Bluff counties.

Test hole reports have been updated to 1989 or 1990 for Cass, Colfax, Dodge, Douglas, Gage, Jefferson, Johnson, Lancaster, Nemaha, Nuckolls, Otoe, Pawnee, Richardson, Sarpy, Saunders, Seward, Thayer and Washington counties.

Test Hole Location Map; revised, 1989 (1:500,000) - $3.50

Morris Skinner's custom matrix-removal system evolved through the years



Side view showing 'pull' cable only

Matrix-removal system devised by Morris Skinner and assistants

This is how my cable-pulley system for overhead removal developed from 1933 on. It started in Devil's Gulch, Brown County, Nebraska. We first used rope, but then used steel cable as common rope didn't last long in matrix and was dangerous when it broke. Likewise, we started using wooden pulleys but soon had to devise our own system of pulleys that wouldn't wear out in the sand or on steel cables. The pulleys kept the cable out of the sand and reduced friction. Even steel cables became worn and were dangerous where they slid over sandstone on slack return trips of the slip. When the strands of wrapped steel wires wore they were sharp as razors.

For power we dug a trail from the top of Devil's Gulch to get a team of horses on Devil's Gulch Horse Quarry so that we could use our quarter-yard, hand-dumped farm slip. [A slip resembles a wheelbarrow without the wheel and with the front edge flattened and sharpened.—Ed.]

On August 16, 1933, we had a near calamity. The slope of the gulch was steep, and after a day of horse work in a circular path to the edge of the matrix dump, the sand gave way. George Anderson (the driver), I, the

slip and the team, all rolled over and over on the talus to the bottom of the gulch—some 100 feet plus. I dodged horses' hooves, harness, log chain and slip to the bottom, but by a miracle, no one was hurt. The horses were well-trained and didn't stampede, but struggled to their feet and stood shaking the sand from their manes and eyes while we untangled the harness, log chain and slip. We took them out of the gulch to the top and later pulled the slip and matrix from the quarry by setting a tall pine pole and pulley in front of the quarry level, then manually pulled the slip back by rope.

That one lucky escape was enough. The gulch was covered with tall pine trees so we had plenty of poles to hang pulleys on to reduce friction [while] pulling matrix to the edge of the former dump. We set a triangular pole tripod at the edge of the bluff to reduce the friction of the rope over the bluff's edge as the horses pulled the slip out to the edge of the dump. Pulling the slip back into the quarry by hand was exhausting and resulted in the "pull-back" idea by using another rope on the back of the slip. Each trip required a separate attachment of the cables to pull and return the slip. Thus we developed the "pull" and "pull-back" cables. Since the quarry was about 250 feet below and out of sight to the driver and team, it was necessary to station a signal man to signal when to pull out the slip to dump, when to return the slip for the next load, and when to stop the returned slip to get positioned for the next load. As simple as it may sound, we soon found there were certain hazards in handling the slip going out and returning.

After we used the rope for pulling out matrix about a week, one time the slip "dug in," but the team kept pulling. The rope broke at a critical point and snapped out over the gulch, cracking like a bull whip. Five to 10 feet of steel rope simply exploded in a shower of shattered strands. This was another experiment we didn't want repeated.

We devised a spring-operated flag so the teamster would know when to stop or pull. This system worked for awhile, but was hard to control and required a flagman who could oversee the work in the quarry. The critical factor was that, on the removal trip, the teamster had his back to the signal flag at the top of the canyon.

We then devised a signal made from a farm disk blade mounted on a log and pulled back from the disk by an old door spring. The striker "bell" operated from the quarry by a quarter-inch rope and could be heard for a [considerable] distance. This of course, required a set of signals for "stop," "go easy," "back," etc. We soon worked out a safe signal system that could be worked from the quarry or whenever we placed the slip in removing worked matrix.

Practically all of our finds or faunal deposits were made in the exposures in the canyons of the area. We devised different methods that worked on the same principle, but instead of horses we used a 1928 Model "A" Ford pickup. Thus, we had power and transport for overhead removal equipment, cables, pulleys, log chains, slip, grease guns, picks and shovels.

The truck, which we called "The Iron Mule" or "Maudie," was treated with great affection and admiration by all bone diggers and resides in one of our barns. It is still visited by old timers and newcomers too. Of course Maudie had her weaknesses too. We devised a "draw bar" on the front of the frame to attach the "pull cables." First we burned out the clutch, which took a lot of time to replace. Then the broken axles, gears, and other parts needed to be replaced. But she served in north-central Nebraska in the Niobrara River canyons, on the Snake River, and in Sioux County. We gave her credit for a large part of our collections.

M. F. Skinner
Ainsworth, Nebraska
December 1980

Marie Skinner reported to the Omaha World-Herald recently that she is restoring old "Maudie," another memorial to Morris Skinner.

More new publications from Conservation and Survey

An Atlas of the Sand Hills: Edited by Ann Bleed and Charles Flowerday (Second and revised edition) 267 p.; $20 - hard bound; $15 - soft bound (Resource Atlas No. 5a)

This atlas examines nearly every aspect of the natural history of the Nebraska Sand Hills, including Indian occupation, settlement, current range practices and "cow-country" lifestyle. Also examined are the climate, geology, soils, groundwater, streams, lakes and wetlands, plants, amphibians and reptiles, birds, fish, mammals and mineral resources. The atlas is fully illustrated in color with photos, fold-out maps, graphs and numerous charts. An index has been included for the second edition.

These 19,300 square miles comprise the largest dune area in the Western Hemisphere. The grass-stabilized dunes, some as high as 400 feet and as long as 20 miles, were formed by blowing sand during a surprisingly recent time, mostly the last 8,000 years. In addition, the area is an ecological meeting ground, where species from different vegetative and faunal regions coexist, creating distinctive biological communities. The sandy soils and underlying sands and gravels have allowed for the accumulation of a vast quantity of groundwater, much of which "outcrops" at the surface. This accounts for another unique characteristic: the dry, dune-top prairie ecosystem beside a wetland, lake, or constantly flowing stream.

Soil Surveys for Platte, Wheeler and Garfield counties (1988): USDA Soil Conservation Service and CSD - $2.50

The soil survey contains information that can be used in land-use planning and decision-making. It contains detailed maps and block diagrams and an extensive text, as well as various tables and a glossary. It contains predictions of soil behavior for selected land uses. It also highlights limitations and hazards inherent in the soil, improvements needed to overcome the limitations, and the impact of selected land uses on the environment.

CALMIT Notes

Scientists exploring limits of new, powerful mapping tools

Software 'brings mappable information together'

by Brad Rundquist
Editorial Assistant, CSD

Not so long ago, all maps had to be produced by hand—a slow and often tedious task. And all analytical functions, even the most mundane, were done by human beings—also a slow process at times.

Thanks to advances made in computer-mapping technology over the last 10 years, that is no longer true. Today, scientists can use a powerful set of computer-mapping and -analysis tools known as geographic information systems (GISs).

Jim Weir, computing supervisor with the Conservation and Survey Division (CSD) at the University of Nebraska-Lincoln, defined a GIS as "a system to bring mappable information together."

He said the technology was developed by geographers and computer engineers to store and organize spatial information within a computer.

A GIS operates as a map overlay system. Many map layers for a given area are produced, each depicting a different attribute, such as elevation, land use, soils, land ownership, zoning, roadways and hydrology. The maps may come from many different sources. But once they are digitized—entered into a computer numerically—they can be interrelated.

Scientists at CSD use many GIS software packages. One of them—ARC/INFO—is the most widely used and perhaps the most powerful available, Weir said. If a line is plotted on a globe, the ensuing curve is an arc, the name of the map-oriented part of the software, he said. And INFO is the name of the database manager that handles the mapped data.

ARC/INFO provides a powerful tool for relating two types of mappable information—the locations of objects and their attributes. In the past, this spatial analysis could be done only by sifting through paper maps and volumes of tabular data. With ARC/INFO, this can be done very quickly on a computer terminal.

But, before data can be analyzed, databases must be developed.

Right now, according to James Merchant, associate director of the Center for Advanced Land Management Information Technologies (CALMIT) at CSD, the primary use of ARC/INFO at the division is in building databases. In the future, he said, more analytical work will be done.

Digitized maps are part of an ARC/INFO database. Paper maps are traced with a hand-held cursor, which converts them to a computer-readable format. Data from satellite imagery can also be entered into the computer.

Attributes describing a digitized map feature—a point, line or polygon—can be entered into tables or as text, he said. This is the INFO part of the software. For example, attributes of a polygon might include its area, perimeter, land use, soil type, average elevation, ownership and census.

The real power of a GIS is not the mapping, but the analysis, Merchant said. The applications of a GIS are enormous and expanding quickly.

The real power of a GIS is not the mapping, but the analysis, he said. The applications of a GIS are enormous and expanding quickly.

However, since GISs haven't been around long, Merchant said, the capabilities of the systems have hardly been tapped.

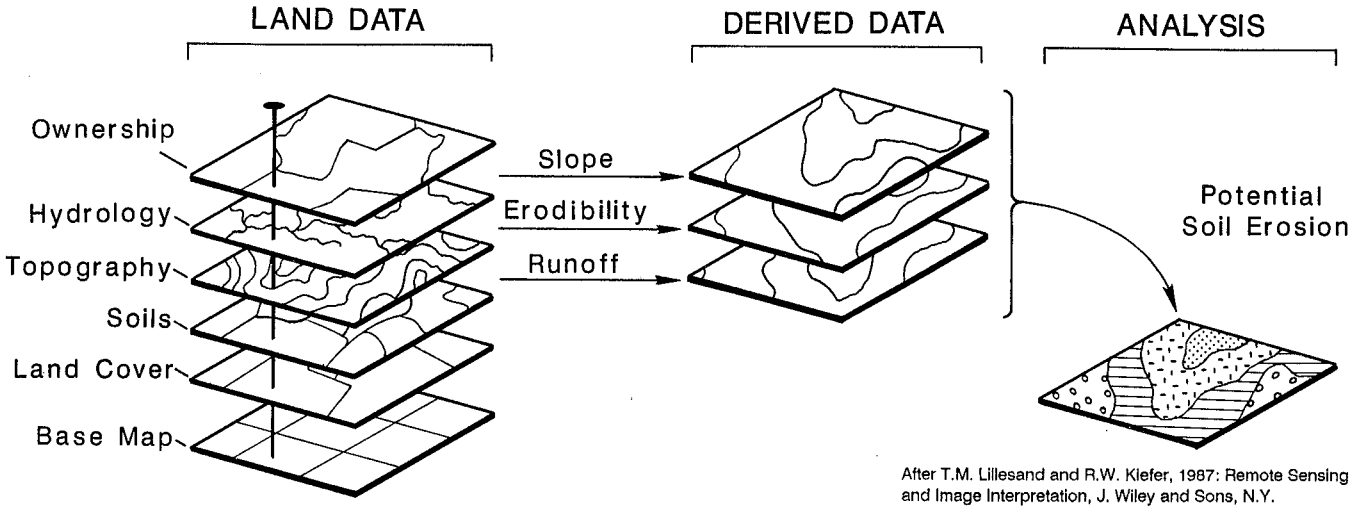
"There's a lot of experimentation to be done," he said. "When people can use a GIS every day, like a word processor, they'll discover things they can do that they never thought of before."

An example of a GIS's analytical capabilities, he said, would be to digitize a map of a road and then enter into INFO attributes such as the speed limit, number of lanes, locations and timing of traffic lights and traffic flow. If a user later needed to know about the road, he or she could display the map on a computer monitor, move a cursor onto the road and tell the computer to display all the information about that road. This is called a query.

A "network" analysis of the road could then be done. This might be used to determine the number of families with children located within a certain travel time from schools. That information could be used to establish school bus routes.

Merchant said a GIS could be a big help for land appraisers. It might be used to evaluate land use, soils capabilities and property ownership to help establish tax rates.

GEOGRAPHIC INFORMATION SYSTEM



An example of the database management and analytical functions of a geographic information system.

In urban areas, the systems can be used to identify the best location for a new school, business or industry. They can also show emergency service workers the quickest route to an accident or fire.

The use of GISs will improve decision making in government, Merchant said. Between 70 and 80 percent of the decisions in county government are based on some type of mappable information, he said. A GIS would allow county officials to make better, more cost-effective decisions and make them more quickly (see story on p. 29).

For example, they probably would want to take advantage of a GIS's ability to analyze alternative land-use scenarios, Merchant said. Using the GIS, they could represent a proposed landfill at several potential sites. The computer could then show how each site might affect the land and people around it.

"There's a lot of experimentation to be done. When people can use a GIS every day, like a word processor, they'll discover things they can do that they never thought of before."

—Merchant

ARC/INFO even lets the user construct "perspective views" to see what the landfill would look like from several positions. After such analysis, the county officials could locate the new facility in the best spot.

"Doing things like examining many alternative solutions to a problem has never been practical before," he said. "It was just too time-consuming."

He said CSD can use a GIS to study and model water pollution, to map irrigated lands and mineral deposits and to evaluate land-use change and the impact of drought on agriculture.

While ARC/INFO is a powerful tool, it does have some faults, Merchant said. For some needs, other software is more appropriate, and CSD has a broad selection of these GIS options.

Since there are few people in the state who can operate ARC/INFO, CALMIT will offer a mini-course, "Advanced GIS Using ARC/INFO." The course complements CALMIT's workshop on "Introduction to GIS."

PC ARC/INFO, a less powerful version of ARC/INFO, will be used in the course. PC ARC/INFO allows students to get hands-on experience using a microcomputer terminal without having to log onto the CSD mainframe computer, Merchant said.

The course is offered June 25-29 and Sept. 17-21 for $550. Anyone interested should contact Donn Rodekohr, workshop coordinator, at (402) 472-2565 or -2567. Another course, "Introduction to GIS," is offered June 18-21, July 16-19 and Sept. 10-13 for $425.

Merchant said there is a definite demand for people who can operate a GIS. In Lincoln alone, five sites use ARC/INFO software.

He expects GIS technology to improve significantly, he said, but doesn't see it ever completely replacing paper maps.

"I see it as more of a complement than a replacement," he said.

In fact, Merchant said, the demand for cartographers may actually go up because they will be needed to design and produce more refined maps generated by a GIS.

"A lot of cartographers would look at the maps currently coming out of GIS and say, 'Those are pretty awful,' and they're probably right. Appearance, design and symbology affect the way information is transferred from a map to the map user, so cartographic input is still, and will always be, needed," he said.

Jerry Leach, chief cartographer at CSD, said he thought

computer maps will continue to need artistic help from human hands.

The systems will change cartographers' jobs, he said. For one thing, they will need a computer background. In some situations, such as when a map stresses the information more than the presentation, he said a computer will probably be used most of the time. But, he said, when appearance is of primary importance, drafting will be used.

Whatever happens, geographic information system technology is here and, according to Merchant, is here to stay. In time, he said, a GIS will be to maps what word processors are to text.

Ground studies examine plant life in ponds

Practical remote sensing system sought to monitor water quality

by Brad Rundquist
Editorial Assistant, CSD

A study undertaken by scientists at the University of Nebraska-Lincoln could lead to a practical method to monitor water quality in lakes and ponds.

Remote sensing systems, mounted on airplanes or satellites, could make it easier to locate bodies of water with quality problems. Information about the tainted water could then be quickly given to those affected.

But, before such a system can be made airborne, ground studies must be completed. These tests were conducted in experimental ponds by the UNL Center for Advanced Land Management Information Technologies (CALMIT) at the Nelson Environmental Studies Area in Kansas in cooperation with Creighton University and the University of Kansas.

Schalles said nuisance growth of algae and benthic plants are a widespread problem in the Midwest because the soils are naturally fertile and runoff to lakes and ponds delivers plant nutrients.

John Schalles, associate professor of biology at Creighton University in Omaha and one of the principal investigators, said researchers were not looking directly for pollution in surface water. Rather, they examined the effects of such stress on aquatic plant life, including phytoplankton algae and benthic (bottom-dwelling) plants.

For example, he said, the effects of plant nutrients derived from runoff, such as nitrogen and phosphorus, are being studied. They generally stimulate plant growth. This can be detected with remote sensing devices by measuring the spectral properties of the plants. These properties involve the way the plants reflect different wavelengths of light, both visible and invisible.

Schalles said the effects of toxic chemicals on water plants have also been studied. The researchers looked at how herbicides, such as the widely used Atrazine, affect the state of phytoplankton and bottom plants.

Finally, he said, researchers are interested in examining how well different aquatic plant types can be identified by measuring differences in their light reflectance. The light reflectance is related both to pigment and structure of the plant.

Right now, he said, he is mainly interested in distinguishing blue-green algae (cyanobacteria) from other phytoplankton. This type of algae is often considered a nuisance and, since it produces endotoxins and exotoxins, can cause severe water-quality problems.

An exotoxin is a poisonous substance given off during the growth of a microorganism. An endotoxin is produced

CALMIT, CSD

Preparing CALMIT's truck-mounted spectroradiometer, a close-range remote sensing device, for use on a pond. Dr. Jerry de-Noyelles (foreground), of the Kansas Biological Survey, positions one of the dilution hoses. Others are (from left) Paul Yamamoto, CALMIT, Mike Schlemmer, CALMIT, and Barb Hayes, of the Creighton University biology department.

by a microorganism, in this case the algae, and given off as the organism breaks down.

The toxins can affect both vertebrates and invertebrates that live in the water, as well as animals that drink it or eat food from it. Possible effects include: odor and taste problems, contact dermatitis in swimmers, gastro-intestinal distress, numbness, partial paralysis and, in rare cases, death. Also, when algal blooms die back, their decomposition can lower water-oxygen levels, resulting in fish kills.

Schalles said nuisance growth of algae and benthic plants are a widespread problem in the Midwest because the soils are naturally fertile and runoff to lakes and ponds delivers plant nutrients. Also, many bodies of water are shallow and usually more productive because nutrients are not diluted and remain in the plant-growing zones.

Man-made bodies of water are fed by streams, which deliver nutrients and pesticides. Runoff from fertilized fields and feedlots in rural areas and sewage and food-processing effluents in urban areas all increase plant nutrients as well.

The first stage of the study was conducted last summer. The specially built ponds were cultured with algae blooms over a period of several weeks.

Donald C. Rundquist, director of the Conservation and Survey Division's CALMIT facility, said spectral measurements were madé at 15-minute intervals during an entire day using CALMIT's truck-mounted spectroradiometer, a close-range remote sensing device. It is capable of measuring reflected light in 256 different wavelength bands.

At the start of the experiment, the pond had a full algal bloom, he said. The water was then diluted all day long, which created a "dilution curve" ending with clear water. The dilution of algal concentrations changes reflectance characteristics so each dilution level appeared slightly different to the spectroradiometer.

Rundquist said the light reflectance from different aquatic plants was measured in the visible and near-infrared wavelengths. The spectral reflectance measured was then mathematically compared to properties measured in the pond water, such as plant concentration, plant type, temperature and water chemistry.

The visible spectrum was for examining chlorophyll because the photosynthetic material absorbs blue and red light and reflects green. The near-infrared was used to detect plants emerging from the pond surface and concentrations of suspended sediments, such as clay.

Last summer, he said, most of the time was devoted to developing methods to make measurements of the pond and learning basic spectral "signatures." This summer, he said, more time will be spent analyzing signatures for blue-green algae and investigating the effects of stress on aquatic systems.

Rundquist presented papers this spring at the annual meetings of the American Society for Photogrammetry and Remote Sensing and the American Association of Geographers that discussed these initial steps toward being able to analyze a body of water from above. Eventually, researchers hope to be able to characterize any body of water regarding its suspended sediment, chlorophyll content, chemistry, temperature and other parameters, he said.

Schalles said that if the initial, controlled phase of the project continues to produce good correlations between the biological measurements and the remote sensing measurements, actual farm ponds will be studied to see if the developed relationships continue to hold up.

Predictive powers of mapping software put to work for National Park Service

Pipestone National Monument in Minnesota to benefit

by Brad Rundquist
Editorial Assistant, CSD

A detailed vegetation map of Minnesota's Pipestone National Monument, produced through a geographic information system at the University of Nebraska-Lincoln, should help park workers better manage vegetation types and plan for better use and development of the park.

This comment comes from James Merchant of the UNL Conservation and Survey Division (CSD), who is overseeing the project. Using ARC/INFO software (see story on p. 24), the division is working with the UNL agronomy department to develop a geographic information system (GIS) of Pipestone, which is in southwestern Minnesota, for the National Park Service.

To make the GIS possible, 12 to 14 digitized map layers must be produced, said Merchant, associate director of the CSD Center for Advanced Land Management Information Technologies. The maps will depict factors that affect vegetation type and distribution, such as drainage, slope, elevation, soil type, historic land-use change and old fence lines.

Theresa Flessner and James Stubbendieck of the agronomy department will collect field samples. The precise location and species will be recorded for each. The data will all be entered into a microcomputer at CSD.

One objective will be to predict the habitats of invading weeds. For example, the user could first tell the computer to look for all the sample sites on which a certain species was found growing. It would find those sites and evaluate the environmental conditions common to all.

Then the data will be analyzed. One objective will be to predict the habitats of invading weeds. For example, the user could first tell the computer to look for all the sample

sites on which a certain species was found growing. It would find those sites and evaluate the environmental conditions common to all.

Then, the computer would be told to find all the other areas in the monument that have the same combination of conditions. The user would expect to find the optimal habitat for that species in those areas.

Merchant said the system will, of course, make some wrong predictions, especially at first.

"They (the users) might not find the plant on the predicted site, or it might be growing a long way from where they were told to look. That's because all the important environmental factors were not considered," he said.

He said the system should perform better after the GIS model has been refined.

The GIS will also help park service workers manage other activities, such as selecting burn areas and wildlife habitat and planning new trails and roads.

The system should be complete by early summer. If all goes well, Merchant said, similar projects will be undertaken for Wilson's Creek National Battlefield in Missouri and Scotts Bluff National Monument near Scottsbluff.

Mapping software creates ready reference for arboretum curators

by Brad Rundquist
Editorial Assistant, CSD

Researchers at the University of Nebraska-Lincoln and the statewide arboretum recently have been working together to develop a geographic information system to aid management at several arboretum sites.

Arthur Ode, director of the Nebraska Statewide Arboretum (NSA), said there are two ways a geographic information system (GIS) helps in managing arboretums. Most of all, he said, it is a very detailed and ready reference to curators. It helps them quickly locate where a certain plant type is growing. It is also helpful, he said, because it can be continuously updated.

The software package ARC/INFO (see story on p. 24) was used by the UNL Conservation and Survey Division (CSD) to produce the maps of three initial test sites: the Lincoln Regional Center, Arbor Lodge State Park in Nebraska City and the Alice Abel Arboretum on the Nebraska Wesleyan University campus in Lincoln. The arboretum has 35 member sites.

Since most of the curators had little or no surveying experience, a simple system to gather data had to be developed, according to John Eno, now with the Lincoln office of the U.S. Geological Survey's Water Resources Division.

"It gave us the opportunity to use the latest technology to do something we normally couldn't (do)."

—Ode

Eno, who formerly worked on the arboretum project at CSD with Donn Rodekohr, facilities manager of the Center for Advanced Land Management Information Technologies at CSD, and Jim Weir, CSD computer supervisor, said the first step was to divide each study site into sections measuring 100 by 100 feet.

Then, Eno said, it was possible to accurately locate each tree or shrub within a section by measuring the distance to the plant from any two adjacent corners of the section. The measurement provided a simple X,Y coordinate that could easily be converted to a computer map.

Each plant was also identified as a deciduous tree, deciduous shrub, coniferous tree or coniferous shrub.

The data were then entered into minicomputers at CSD. Each tree type was assigned a different symbol and placed in the proper location on the digital grid. A second map layer, showing roads, sidewalks and buildings, was also created. The two were combined to produce the final map.

The final products were a large wall map and a field manual for each site.

Ode said he was extremely pleased with the results.

"It gave us the opportunity to use the latest technology to do something we normally couldn't (do)," he said.

NSA has made a request for a grant, Ode said. If the request goes through, he said, more sites will be mapped.

Eno said the project demonstrated the ease with which a site inventory can be done. A tape measure, paper and a pencil and ARC/INFO are all it takes.

Arboretum workers calculating the distance of a planting from the 100-foot by 100-foot grid to provide an X,Y coordinate of the tree's location for ARC/INFO.

CALMIT, CSD

City, county governments may benefit most from geographic information systems, surveyor says

Local governments may have the most to gain from geographic information system technology, according to the Lancaster County Surveyor.

Larry Worrell said that the ability of a geographic information system (GIS) to integrate data and make analytical predictions makes it very attractive to various departments of city, county and state governments, many of which are beginning to use this type of technology.

A GIS can provide a better cost-benefit ratio for each tax dollar, he said. But to date few political subdivisions in Nebraska have been willing to consider these new methods. However, Lancaster County has had a total GIS package for about a year.

Worrell is presently using a global positioning system to accurately locate all of the section and quarter-section corners in Lancaster County. Through this procedure, he is creating an accurate base-mapping system for a full GIS.

The use of an integrated system, he said, would more effectively link information about deeds, taxation, building and health permits, soils analysis, planning, zoning and emergency-response stations.

Once the data is in place, decision makers would have ready access to easy-to-understand information, he said. Furthermore, by using an integrated GIS for modeling and analytical projections, a "higher and more confident level of decision making" could be provided, he said.

Departments in city, county and state governments are very segregated, Worrell said. Many departments and agencies have public information that could be used more efficiently through a GIS, rather than having to walk from department to department, accumulating reams of data that still need to be compiled.

In addition, one never has to "reinvent the wheel," he said, because such a system can be updated when changes occur.

—CALMIT Notes

Sand Hills drilling should continue, director says

Drills stand idle until funds are found

Regional test drilling by the Conservation and Survey Division and the U.S. Geological Survey will not be done this year—unless funds are found—for the first time in the program's 61-year history.

Funds to continue drilling in 1990 were cut off because interest in thoroughly testing the Sand Hills has subsided, said Perry B. Wigley, director of the University of Nebraska-Lincoln Conservation and Survey Division (CSD). He said that site-specific holes will probably continue to be drilled, however.

To date, the test-drilling project is about 90 percent complete, with 4,447 test-holes drilled. The majority of the lands that remain to be tested are located in the Sand Hills.

When the test-hole program was started in 1930, finding water in the Sand Hills was a problem. Since water is now easily found and irrigation has been developed, there isn't much interest in continuing the project in that part of the state, Wigley said.

"That's unfortunate," he said. "I feel that the time to be doing studies is when there isn't a problem, so when there is, there won't be a knee-jerk reaction."

The Nebraska Natural Resources Commission had been supplying $80,000 annually to the project. At least that much is needed to continue the drilling, Wigley said. CSD is presently trying to secure the money through the NRC or other agencies, he said.

Getting the program financed is complicated by the fact that Nebraska already has more test holes than any other state.

"It's sometimes hard to make people realize that the project is still important," he said.

He said test drilling is important in Nebraska because there aren't many surface outcroppings of rock in the state. The test-holes tell scientists and others much about the state's geological history and composition, as well as providing important information about aquifers and groundwater.

"Test drilling is very important to us," he said. "It has been the backbone of the division for 60 years."

CSD drilling is usually done on public lands and follows a systematic sequence. Test holes are spaced about 6 miles apart in a north-south and east-west pattern, along township boundaries. Occasionally, the pattern is varied slightly for topographic, economic and land-ownership reasons. CSD has drilled in all 93 Nebraska counties.

In the 1930s and 1940s, drilling was done primarily in valleys, where to depth to water is relatively shallow. Also, several areas of concentrated drilling exist where specific research projects were conducted.

Logs of all test-holes are available from CSD. Several county log books have recently been updated to include more recent test drilling.

Information concerning Nebraska's 3,600 groundwater observation wells, found in the annual report, "Groundwater Levels in Nebraska," is also available from CSD.

Test drilling in days gone by: A photo essay

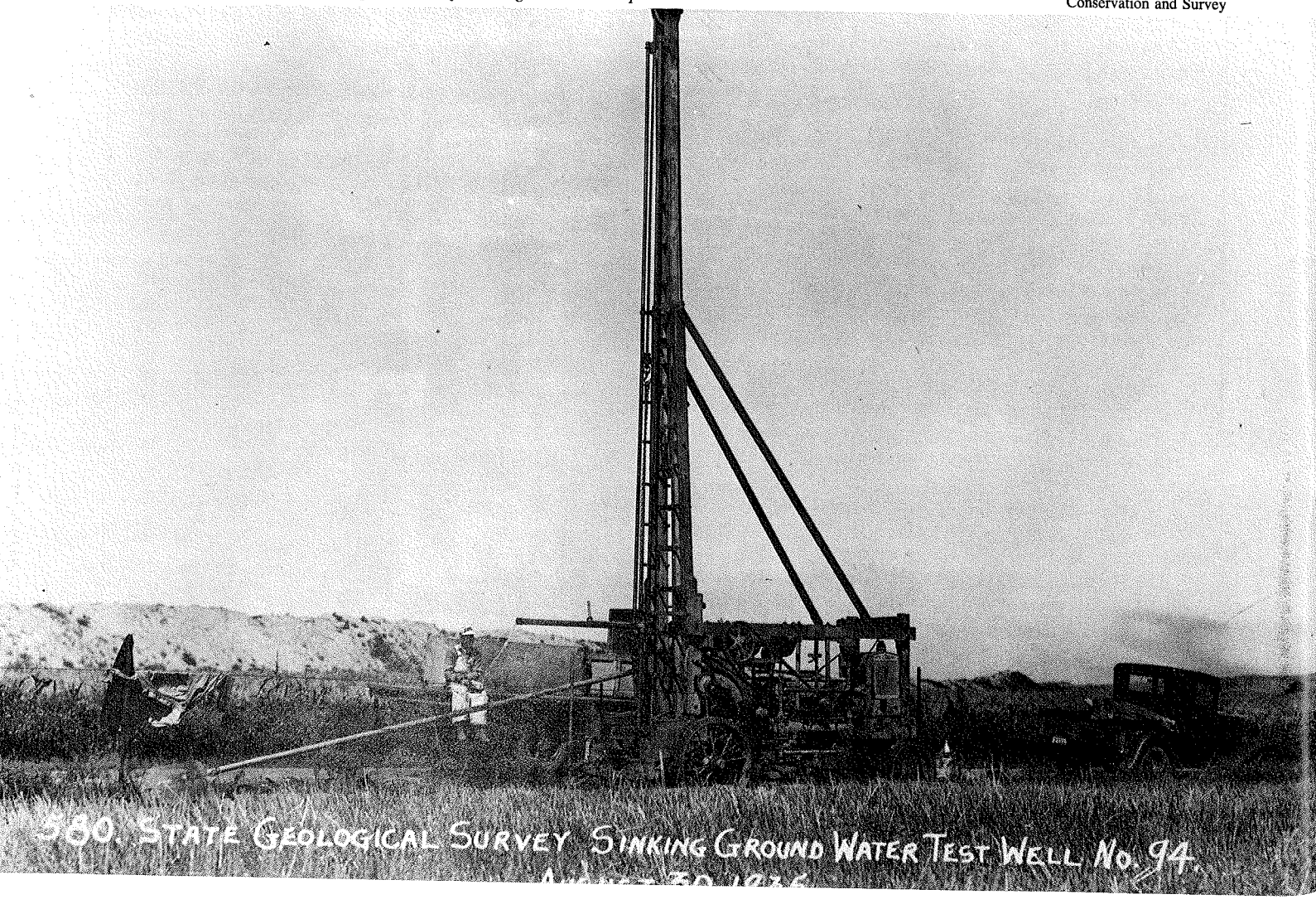
Editor's note: Even though by the early 1980s Conservation and Survey was subcontracting nearly all its test drilling, from the early 1930s until then, test holes were drilled in nearly every county in the state by CSD staff with CSD rigs. Test drilling may seem a rather unremarkable enterprise to the uninitiated. But to a geological survey in a state with few outcrops, it is a necessity, practically a life's blood. In fact, Nebraska has drilled more test holes than any other state in the nation. Without the knowledge gained from such drilling, the whole state would be poorer, not just intellectually, but economically. Intelligent development of groundwater resources, among others, depended on it, particularly in an agricultural region prone to below-average precipitation.

Test drilling is often long, hard work in the hot sun, but it can also take place in near-freezing or sub-freezing temperatures. It requires constant supervision and concentration, entailing the threat of losing fingers or limbs if one is careless. It often goes on into the night or early morning and generally occurs many miles from food or shelter (water is a necessity, however). The sheer logistics of maneuvering a rig into place can be exasperating and exhausting (note the photographs of the drilling on a Missouri River island), particularly if equipment gets stuck in mud or sand. Samples must be caught in order and their lithology recorded carefully. If the crew is moving on to drill another hole in another place the next day, the person running the geophysical equipment must log the hole then and there, a task that often takes until midnight or later.

In addition, test drilling has produced its share of colorful characters and events, past and present. Some of these are related pictorially through a photo essay of the early days of test drilling compiled by CSD drill rig operator and mechanic Gene Debus, CSD cartographer Jerry Leach and Duane Mohlman, a CSD editorial assistant. Another glimpse that follows is provided verbally in an interview with Debus concerning his drilling experiences.

CSD drills a test hole 4 miles northwest of Columbus with a rotary-hydraulic rig made by the Dempster Manufacturing Co. The Loup Canal can be seen in the background, 1935.

Conservation and Survey

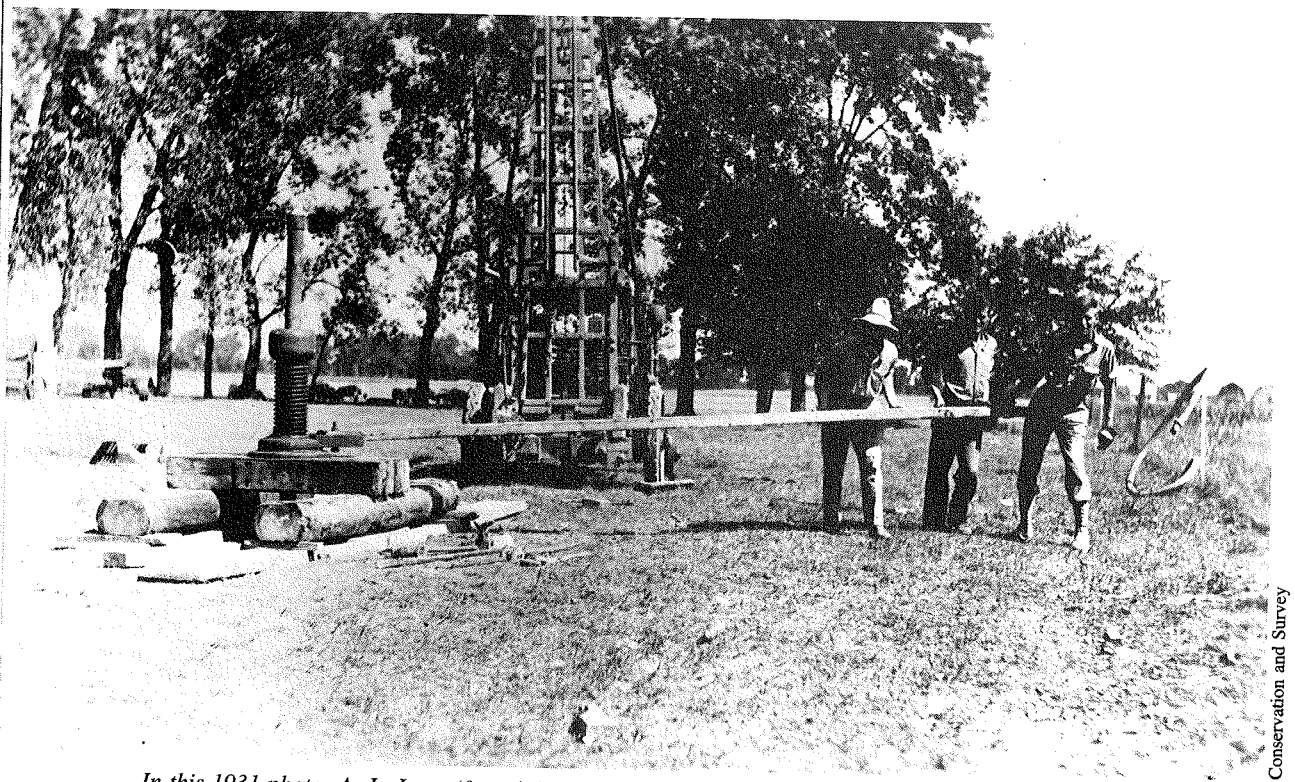


In the early 1940s, Nebraska City had water-quality problems because the city obtained its water directly from the Missouri River. Nebraska City hired Henningson Consulting Engineers of Omaha to find a suitable water supply for the city. Henningson contacted CSD for assistance in the drilling of test holes. Ellis Gordon (third from left), CSD, was sent to the proposed site. A barge was hired to transport the drilling equipment to a small island on the Missouri River. The salary of the geologist and head driller was $129.17 each per month.

Conservation and Survey

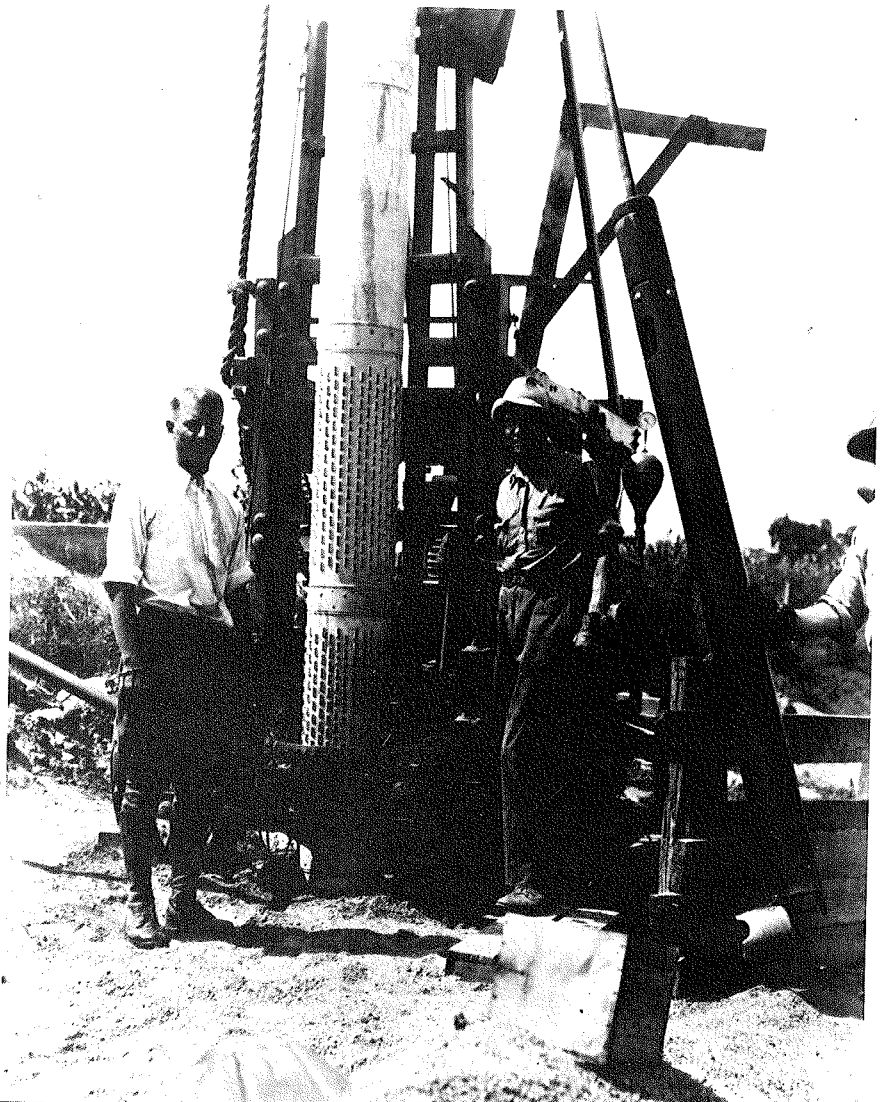
Conservation and Survey

Backing the drill rig onto an island in the Missouri River during the Henningson Consulting investigation.



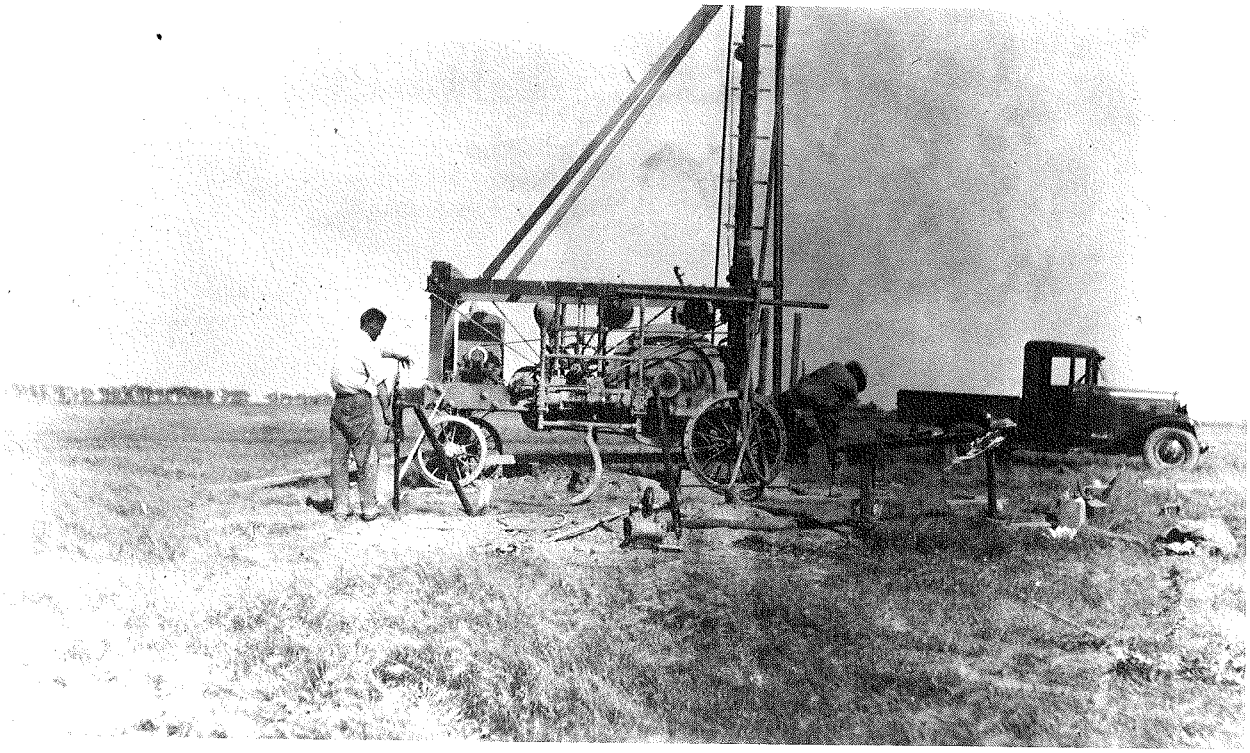
Conservation and Survey

In this 1931 photo, A. L. Lugn (from left), Harry Burleigh and a man known only as Miller are using a retractor to retrieve a section of 3-inch pipe stuck in some gravel when the hole caved in. This shows a rear view of the new Dempster rotary-hydraulic rig. The rig had a wooden mast mounted on a trailer assembly. The Dempster cost $3,600 and was used for nine seasons.



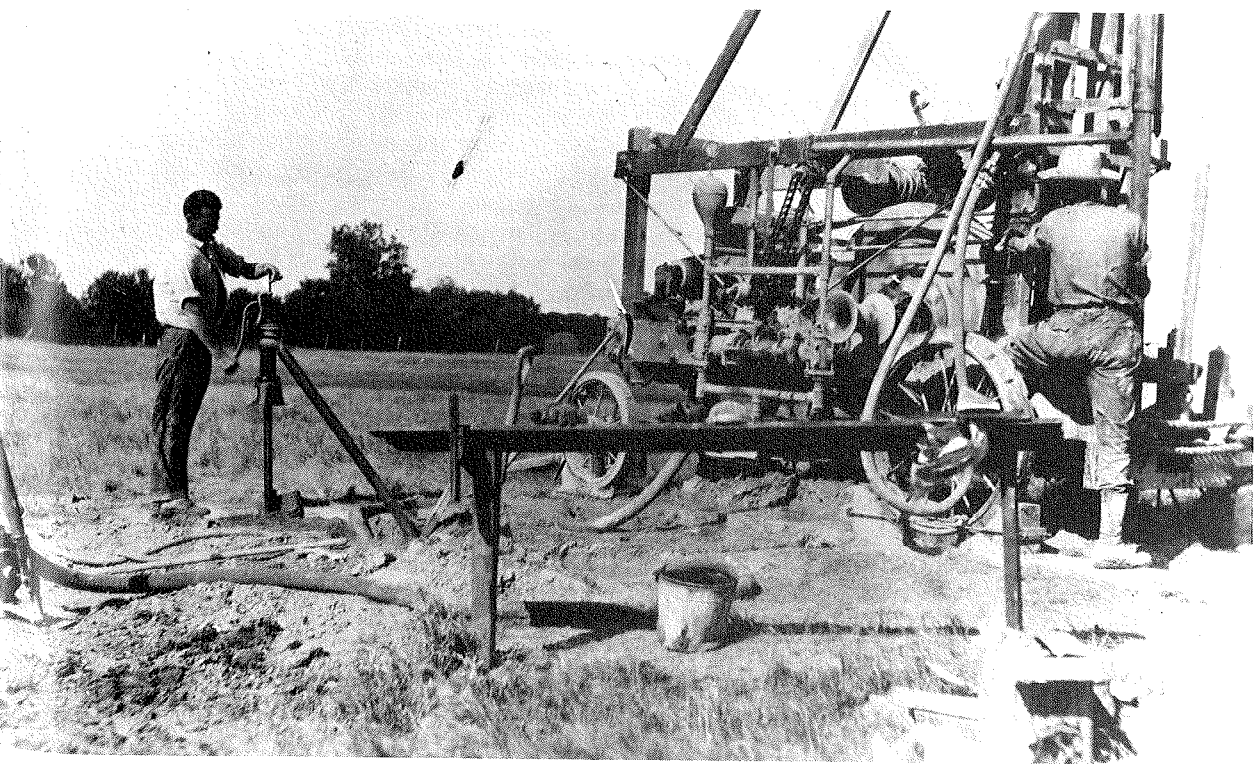
Conservation and Survey

Miller (from left; first name unknown), Harry Burleigh and A. L. Lugn lower the screen and casing into the hole drilled by the Dempster rig.



Conservation and Survey

Harry Burleigh (left) is pumping water into one of two nearby mud pits. Miller (first name unknown) stands beside the rotary-hydraulic Dempster rig that is drilling a 3-inch test hole. In the mud pit, clay is mixed with the water to form a mud solution. The mud solution is then taken from the pit by the rig's suction hose and pumped down the drill stem. The mud solution hardens and acts as a casing to help prevent cave-ins, as well as bringing the samples to the surface. This return solution flows into the second mud pit, where the cuttings settle out. The wooden table in the foreground is used to lay out samples for closer inspection and record-keeping.



Conservation and Survey

To Debus, drilling danger is part of the challenge

by Brad Rundquist
Editorial Assistant, CSD

There are many things that can go wrong in test drilling. But that's part of what makes it interesting and challenging. At least drill rig operator and mechanic Gene Debus thinks so.

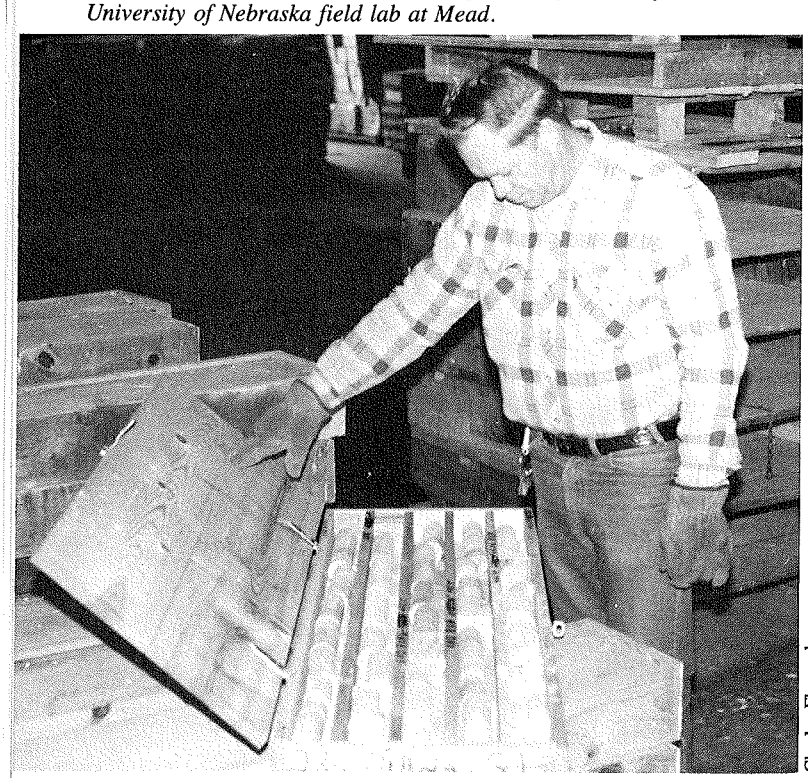
Debus, who has been with the Conservation and Survey Division (CSD) since 1964, has helped drill test holes in just about every area of the state but the northeastern corner. He's even drilled in parts of Iowa and South Dakota. The deepest hole he's worked on was 880 feet in Custer County, although some holes now are drilled in excess of 1,700 feet.

He said his job is to check footage, watch the mud-pump pressure, watch the drill speed and keep track of where everyone is. The mud pump moves drilling mud, a clay-and-water mixture, into the hole during drilling. This mud hardens along the walls to prevent a collapse.

While working on a CSD van that houses the electric logger and other geophysical equipment used in drilling, Debus recalled some of the good, bad, and even ugly drilling experiences he has had.

The best part of the job, he said, is being outside and meeting the challenge of completing each hole. But there is constant danger during the 18 to 19 hours it often takes to complete a job.

Gene Debus, drill rig operator and mechanic for CSD, examines a box of drilling cores at the CSD sample storage building at the University of Nebraska field lab at Mead.



Charles Flowerday

"You never know when a cable is going to break," he said. "There are a lot of things that come without warning."

He said that if a cable does break, it can whip around and cause the drill stem to drop into the hole.

"And if the cable does hit you," he said, "it can knock a you down, or out."

The scariest thing that ever happened on the job, he said, was one rainy night during the 1960s. While he and the crew were drilling, one of the workers accidentally picked up the ground-wire for the electric logger, which sent 110 volts through another who happened to be pulling up the probe.

"You never know when a cable is going to break. There are a lot of things that come without warning."

—Debus

"He just about got electrocuted," Debus said.

A device to prevent such an occurrence has since been developed.

In 1988, CSD replaced its old Widco electric logger with a new geophysical logging system and refurbished a van to house the systems. More downhole tools and equipment were added to the system in 1989, which brought the total value to around $100,000. Jerry Ayers, CSD research hydrogeologist, said the new equipment will greatly improve CSD's borehole logging capability.

The test-hole program, a cooperative effort between the U.S. Geological Survey and CSD, started in 1930. Since 1951, test holes have been logged with electric loggers.

During drilling, the timing of each 5-foot increment is accurately recorded. Samples from each 5-foot interval or less are evaluated by CSD geologists. Samples are then washed, described by rock formation, and their color is compared to standard color charts. All samples are then returned to CSD, where they are further evaluated, cataloged and filed.

Since about 1985, CSD hasn't done much test drilling with its own equipment. The division has found it more economically feasible to contract with private drillers. He still goes out with the contract drillers if they need another man, Debus said, and the CSD rig is now used mostly for research projects.

However, economics is not the only reason CSD is making extensive use of contract drilling. The division presently has the capacity to drill between 700 and 800 feet deep. Recent test holes can go much beyond that depth. For example, all 14 test holes drilled in 1989 were between 800 and 1,790 feet deep.

'Little sacks of dirt' represent heartbreak, fortunes

Hueske handles 'a treasure house of information' in sample library

by Duane Mohlman
Editorial Assistant, CSD

Ken Hueske says he finds a certain sense of romance in his job. Some of the oil and gas test drilling samples for which he is responsible, for example, represent "a lot of broken hearts," he says, "as well as fortunes to be made, and all that's left is a lot of little sacks of dirt."

But, Hueske explains, those "little sacks of dirt" can yield vital information that can help a geologist, soil scientist, engineer, builder or anyone else seeking subsurface information.

Hueske works in the Conservation and Survey Division (CSD) sample library, which contains samples from some 20,000 holes drilled in Nebraska. Besides the division's own test-hole drilling program, samples are routinely received from commercial drillers of test holes for water, oil and gas and other minerals. The Nebraska Department of Roads, the U.S. Army Corps of Engineers and U.S. Bureau of Reclamation also send samples. Even when not required, commercial drillers send samples to CSD.

Hueske, sample library supervisor, estimates that CSD receives samples from about half of all the holes drilled in Nebraska.

"Just as the (state) historical society is in charge of preserving history, we are in charge of storing and preserving the wealth of mineral and natural-resource knowledge in Nebraska."

—Eversoll

The CSD sample library is, Hueske says, "a treasure house of information."

But why keep such an enormous supply of samples? The reasons are as varied and numerous as the individuals and companies who use the library.

The main reason is that CSD is mandated by state law to house them permanently because a repository of geological knowledge about Nebraska was needed.

Duane Eversoll, a CSD research geologist, explains, "Just as the (state) historical society is in charge of preserving history, we are in charge of storing and preserving the wealth of mineral and natural-resource knowledge in Nebraska."

Also, the inventory saves many companies much money because, with a ready reference, they don't have to do their own test drilling. The library's duplicate samples can be used for research and as definitive proof of the subsurface characteristics at any given location. Duplicate samples are valuable because they are expendable for research and testing.

The samples that Hueske oversees are of two types: rotary cuttings and core segments. Rotary cuttings are loosened by a drill bit and flushed to the surface during drilling. Cores are cylindrical segments of earth that are cut out by special bits and then brought to the surface intact.

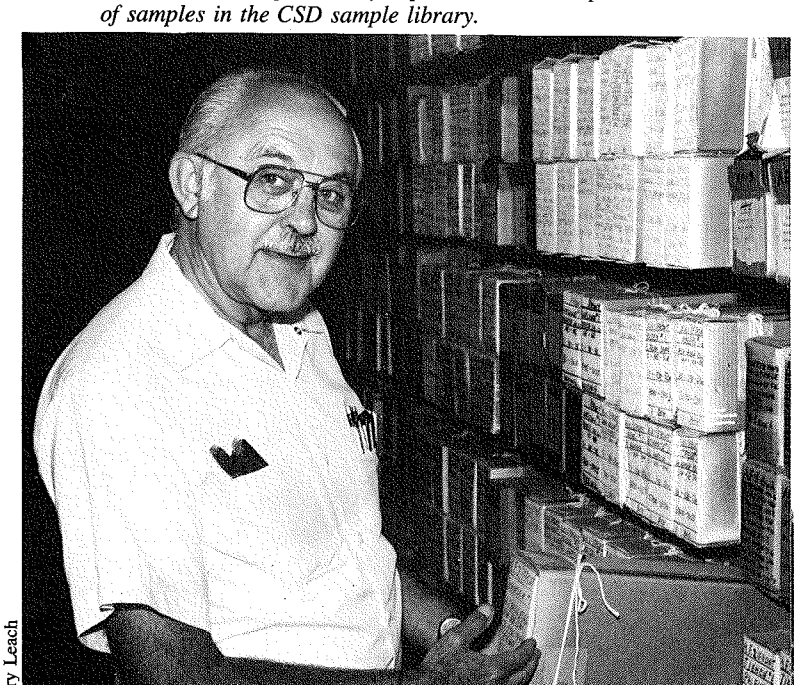
Hueske estimates the sample library receives samples from 100 test holes per year. In 1989, samples from 80 test holes were received, 39 from oil and gas tests.

He said samples arrive in many forms and containers, frequently still wet from drilling. Hueske said a critical first step is to obtain an accurate location for the test-hole. Then the samples are "cut," that is, a representative portion is placed in appropriate containers, clearly labeled, cataloged and filed.

As one might expect, the space requirements to house the samples are enormous. CSD now houses the samples at four locations in and outside Lincoln. The first place is in the division offices, the one Hueske affectionately calls "sample headquarters." Here, CSD keeps samples from its own test-hole drilling program, as well as samples currently used by division researchers.

At the nearby Geo-resources Building, just north of Nebraska Hall, samples used for special projects are housed. For example, samples were stored and studied here during the recent search for a new Lincoln landfill. In the Annex, on the UNL East Campus, most of the samples received from the oil industry are stored.

Ken Hueske, sample library supervisor at CSD, pulls out a box of samples in the CSD sample library.



Jerry Leach

Finally, at the UNL Agricultural Research and Development Center near Mead stands CSD's largest sample-storage building. This building contains samples from completed projects, some duplicate samples and samples from federal drilling programs.

Needless to say, sample storage space is becoming quite a concern. Most of the storage space at the four locations is at, or near, maximum. CSD is looking for a building that could house the entire sample library.

Designing a building in which temperature and humidity can be controlled is very important, Eversoll says. Without a constant environment, sample containers and some rock fragments can be damaged due to the wild temperature fluctuations and high humidity in Nebraska.

The sample library is used mostly by CSD staff. But, many staff members recall times when others have profited from the information.

Graduate students working on theses and dissertations have often studied CSD samples. Researchers and consultants from all areas, scientists from the oil industry and the U.S. Department of Agriculture Soil Conservation Service, engineers from the state roads department and numerous other government agencies have all used the library.

Surprisingly, it is staffed by only one full-time employee and one part-time geology student. But, Hueske says, being the only "full-timer" has its advantages. For instance, he can maintain a uniform storage system.

Most of the samples, and all the related interpretations and information produced by CSD staff are available for inspection by any interested party. Of course, some samples are kept confidential—for example, recently received oil and gas samples. A filing system is available to assist anyone in the search for samples.

Once life-givers of the plains, windmills still water a thirsty land

by Pat Larsen
Communications Associate
NU Water Center

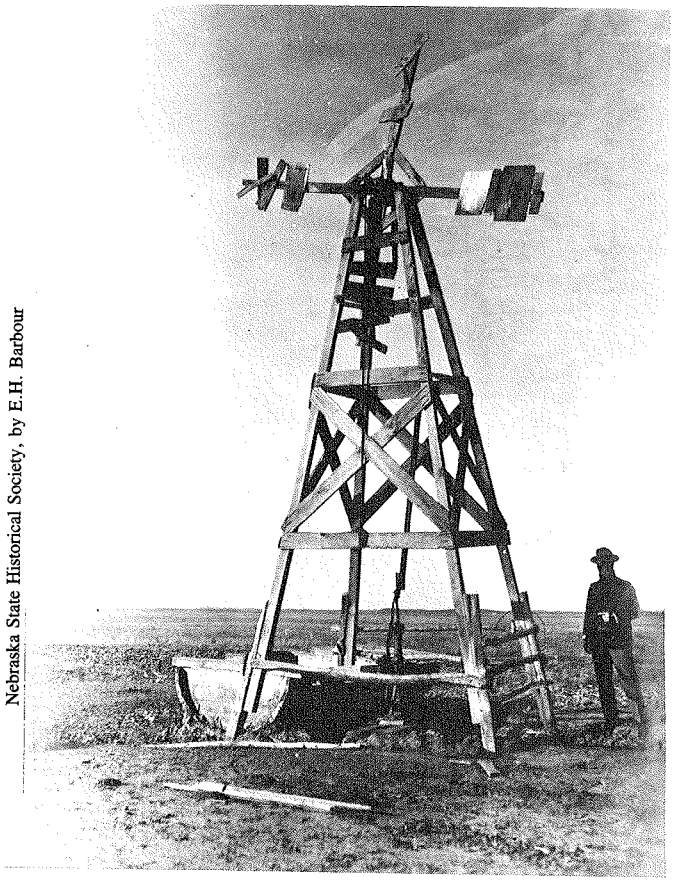
Dotting the rural countryside, sometimes entwined with morning glories, they remind passers-by that in the late 19th century they were an answer to a farmer's prayer for water for his family and livestock, or even to irrigate his crops.

Windmills were introduced in the United States about 500 years after they appeared in Holland. There they drained the land by pumping water into the sea from behind the dikes.

Their legacy spread through Europe: 300 years ago, Don Quixote's epic, "The Man of La Mancha," described the mythical pursuit of windmills imagined as battle-worthy foes on the austere plateau of La Mancha in central Spain.

But while tilting at windmills has been symbolic of a futile fantasy, in reality the windmill, very early on, was a symbol of life.

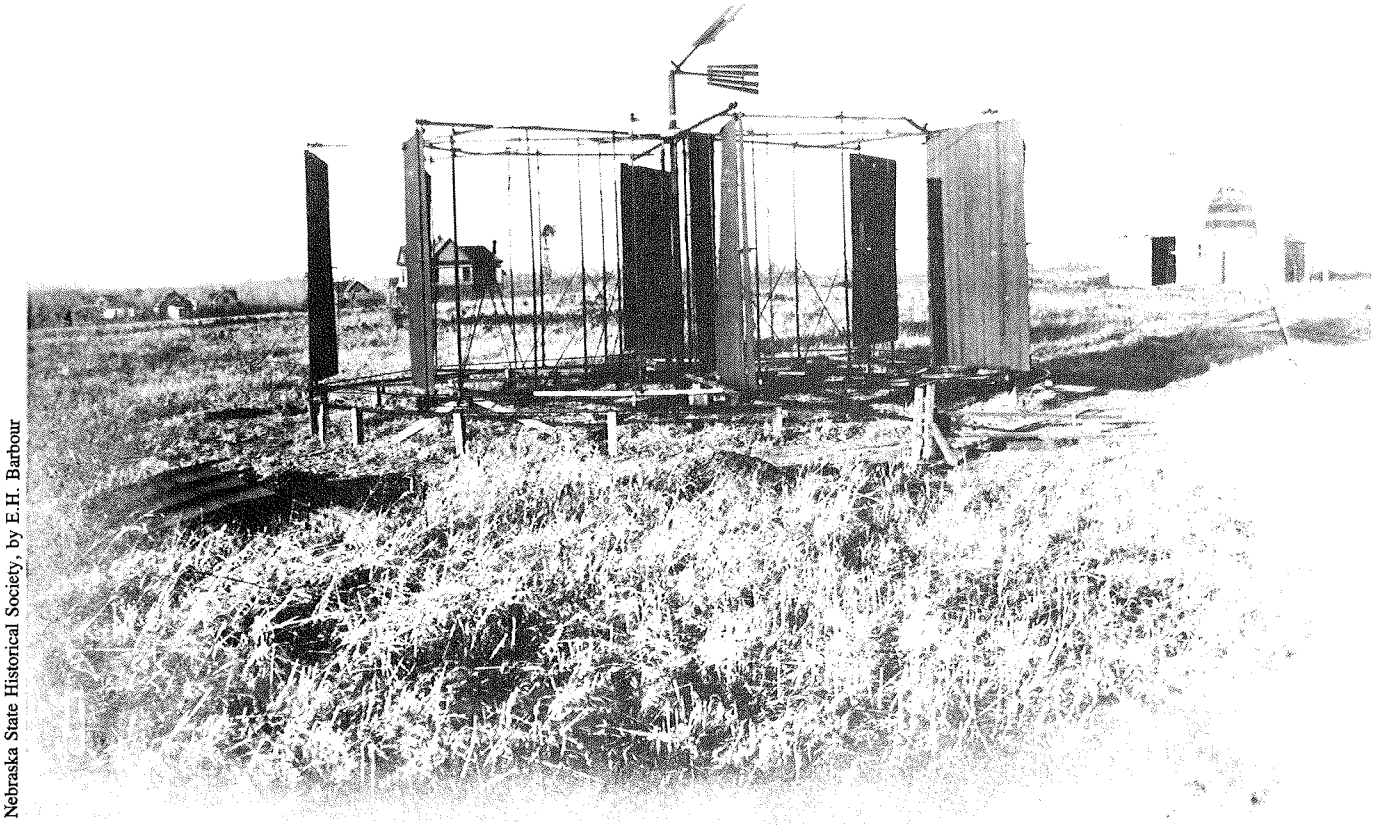
P. Hargen's four-fan battle ax mill, Grand Island, Hall County, Neb., Dec. 27, 1898.



Nebraska State Historical Society, by E.H. Barbour

Stationary steel turbine mill, built by the Janak Brothers, ca. 1898. Runs machinery for a shop.

Nebraska State Historical Society, by E.H. Barbour



Nebraska State Historical Society, by E.H. Barbour

A "merry-go-round" mill near Lincoln, Lancaster County, Neb., ca. 1898. Designed by S.S. Videtto.

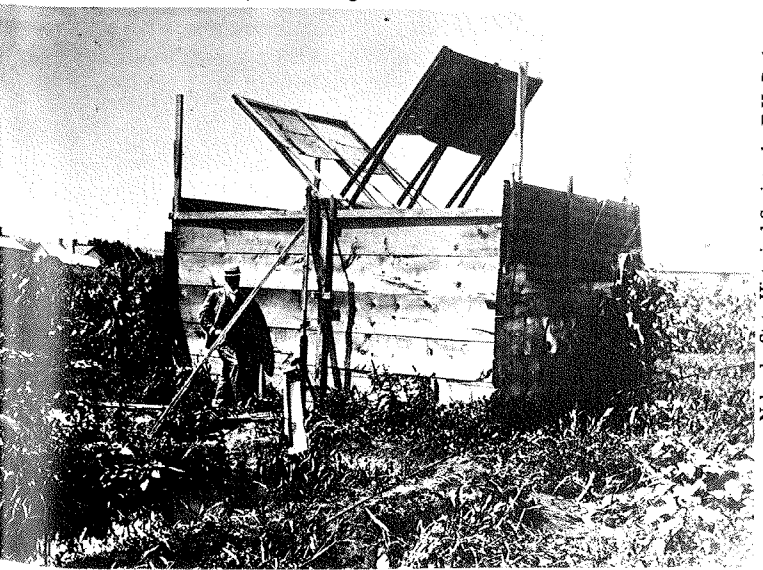
Back on June 14, 1759, at a meeting of the Royal Society in London, John Smeaton read a paper "On the Construction and Effects of Windmill Sails," that eventually led to research in Batavia, Ill., on a device called a "wind wheel." This research on the wind wheel, published in 1883, was one of the first sources of information about wind velocity, sail area, spacing and friction that helped perfect the windmill, later recognized as a giver of life to the Great American Desert.

Closer to home, Erwin Hickley Barbour, University of Nebraska professor of geology and state geologist from 1891 to 1921, published Water-Supply Paper No. 29 with the U.S. Geological Survey in 1899, entitled "Wells and Windmills in Nebraska." Barbour, coming to Nebraska with a Ph.D. from Yale, was the third state geologist and head of the Nebraska Geological Survey, a precursor to the Conservation and Survey Division at the University of Nebraska-Lincoln. He later went on to be director of the NU State Museum and its natural history collections.

"The windmill has long been the popular means of raising water for domestic use and for watering stock, and now, in addition, it comes to enjoy the recognition it deserves as one means of irrigating land where other means are wanting."

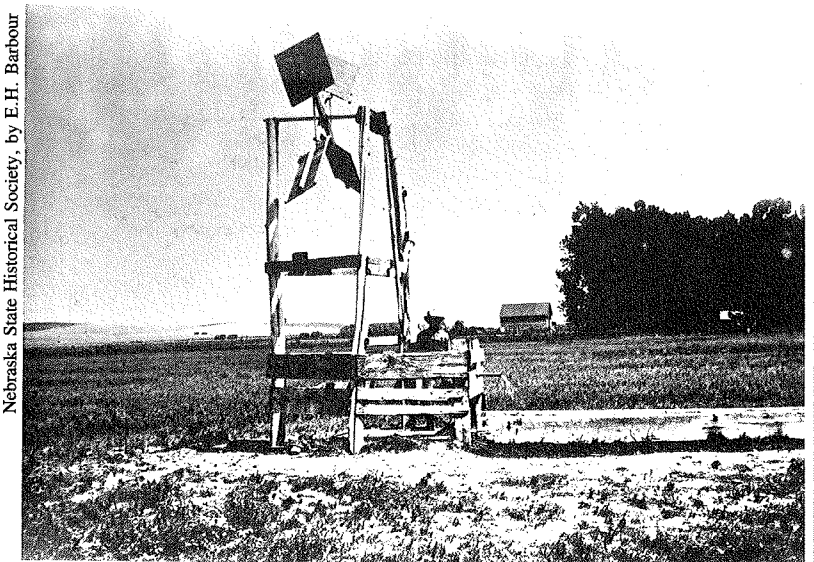
—Barbour, 1899

Travis Brothers jumbo, Lincoln, Lancaster County, Neb., ca. 1898. Irrigates 5 acres (of) market garden. Cost—$8.



Nebraska State Historical Society, by E.H. Barbour

Matthew Wilson's battle ax mill near Overton, Dawson County, Neb., Aug. 18, 1898. Pumps water for stock. Cost—$1.50.



Nebraska State Historical Society, by E.H. Barbour

He noted that due to drought from 1892 through 1895, "the whole water table was lowered" and many springs, ponds, streams and wells failed. Barbour described methods of "hoisting water" to provide for the needs of humans and animals.

"The windmill has long been the popular means of raising water for domestic use and for watering stock, and now, in addition, it comes to enjoy the recognition it deserves as one means of irrigating land where other means are wanting," he said.

"The whirling mills are necessary accompaniments of Nebraska scenery. Their work is admirable, though impossible feats are often expected of them. As the matter of windmill irrigation is agitated, the receptive mind of the progressive farmer seizes the idea."

Barbour foresaw windmill irrigation as one of the important factors in the development of Nebraska's agricultural resources.

"I would estimate that about 10,000 windmills are used in Nebraska today. Windmills are used mostly to provide range water for cattle in both eastern and western Nebraska."

—Muller

"Already farmers are irrigating with profit from 1-acre to 50-acre tracts by means of one or more windmills," he noted.

The nation's expansion into the semiarid and arid West was greatly aided by windmills and barbed wire. Windmills emerged above hand-dug wells throughout the plains in the late 19th century.

Updating the evolution of these whirling wheels, Marty Muller, of Muller Industries in Randolph, said that windmills are still used in the western part of the state. Muller Industries has manufactured and stocked parts for windmills since the early 1900s.

"I would estimate that about 10,000 windmills are used in Nebraska today," he said. "Windmills are used mostly to provide range water for cattle in both eastern and western Nebraska."

The demand for windmills is seasonal, and Muller Industries moves about 300 to 400 rebuilt windmills in the spring and summer.

"It all depends on the cattle market," he said.

And at Beatrice, Dempster Industries, Inc., manufacturer of windmills since 1878, sells about 200 windmills each year, according to David Suey, executive vice president, and former president of Aermotor Mfg. Co., another windmill manufacturer. He said that the windmills are used mostly on small acreages. Some go to such places as Colombia, Venezuela, Equador, and the Caribbean islands, as well as to Chad and Sudan. A few go to California for cattle watering.

At the peak of the windmill era in the late 1920s and early 1930s, Dempster Mill Manufacturing Co. made about 10,000 to 15,000 windmills annually and ranked about tenth in the production of windmills among the 100 firms in the nation that made about 250,000 a year. As the countryside became hooked up to electricity through the Rural Electrification Administration, the need for wind power began to decline.

Nebraska State Historical Society

"The Boss," Hammond Brothers, Randolph, Neb., date unknown, perhaps shortly after the turn of the century.

Now, Dempster also makes water-systems pumps and fertilizer and chemical applicators for the agricultural industry.

"We still make parts, though, for some of those windmills that are still standing," Suey said. "You can repair a windmill forever in the plains states." Those who repair these sentinels of the plains are known as "windmillers."

"Windmills have always needed several ingredients to justify themselves," Suey said. "Wind, animals, people and thirsty land.

"Lots of old-timers are sentimental about their windmills," Suey pointed out. "Lots of windmill sales and repair are for folks that may have an electrical wire directly over the windmill, especially in California," he said. "Sometimes they're more ornamental and symbolic than functional."

Meanwhile, at Cordoba, population 130, about 8 miles south of Interstate 80 at the Utica exit in Seward County,

the windmill is the town symbol, standing majestically in the village square, a reminder of its role in local prosperity.

However, in Nebraska, the most predominant monument to the formerly life-giving qualities of the windmill is Windmill State Recreation Area, at the Gibbon I-80 interchange, between Kearney and Grand Island. Travelers today who stop to use the camp facilities adjacent to this 14-acre reservoir can appreciate windmills from the past: a railroad windmill that is more than 60 feet tall; a Colorado windmill from about 1890 that was moved to Kansas and later found a home at York; a Waupans windmill erected in 1902 at Arcadia; and a 1910 Dempster Model 9 windmill, all in working condition.

This area, historically known as Windmill Crossing, was where Pawnee Indians crossed the Platte River during their annual buffalo hunts. Operated by the Game and Parks Commission, it has been a stop-off point for generations of travelers.

New soils map due out soon

The Soil Survey of the Conservation and Survey Division will soon publish a new 1:1,000,000-scale general soil map of Nebraska. The 16'' x 33'' map features a minimum of 80 soil associations and uses more than 30 colors.

The map's scale is a new feature in the Nebraska soil map series, said Mark Kuzila, head of the soil survey. The most detailed soil maps available, with 1:20,000 and 1:24,000 scales, are those found in county soil survey reports. Currently, those reports can be obtained for more than 80 percent of the state.

A set of 11 general soil maps published on U.S. Geological Survey quadrangle base maps, at a scale of 1:250,000, constitute the next level of soil map detail. In addition, the much broader page-size general soil map shows the whole state at a glance.

The 1:1,000,000 scale provides an interesting medium, Kuzila said. It has good detail and is still concise enough to be easily read, he added.

The new map should be available this summer and can be ordered from the Conservation and Survey Division, 113 Nebraska Hall, University of Nebraska, Lincoln, 68588-0517. Nebraska residents should add state and city sales tax. Please specify SM-3 (Soil Map No. 3) when ordering.

Selected publications related to this issue

Publications

—***Soils in Nebraska:*** J.A. Elder (1969) - $3.00 (RR-2)*

—***Groundwater Quality of the Central Platte Region, 1974:*** M.E. Exner (Spalding) and R.F. Spalding (1976) - $7.00 (RA-2)

—***Groundwater Quality Atlas of Nebraska:*** R.A. Engberg and R.F. Spalding (1979) - $5.00 (RA-3)

—***The Groundwater Atlas of Nebraska:*** R.D. Kuzelka and D.T. Pederson, project leaders (1986) - $3.50 (RA-4)

—***Effects of Land Use and River Seepage on Groundwater Quality in Hall County, Nebraska:*** R.F. Spalding (1975) - $3.50 (WSP-38)

—***Test Hole Reports:*** Available for most counties in Nebraska - Price varies

Reprints

—***Evaluation of Nitrate Content of Ground Water in Hall County, Nebraska:*** *from* Ground Water, November-December, 1973, Vol. 11, No. 6: Rauf Piskin - $1.50 (RS-4)

—***Rain is a Sometime Thing:*** *from* Farm, Ranch and Home (IANR) Quarterly, Summer 1975: Ray Bentall - $.50 (RS-11)

*Order numbers in parentheses at end of each entry

—***Nonpoint Nitrate Contamination of Ground Water in Merrick County, Nebraska:*** *from* Ground Water, Vol. 16, No. 2, March-April, 1978: R.F. Spalding, J.R. Gormly, B.H. Curtiss and M.E. Exner (Spalding) - $1.50 (RS-20)

—***Evolution of Contaminated Groundwater in Holt County, Nebraska:*** from Water Resources Research, February 1979, Vol. 15, No. 1: M.E. Exner (Spalding) and R.F. Spalding - $1.50 (RS-25)

—***Sources of Concentrations of Nitrate-Nitrogen in Ground Water of the Central Platte Region, Nebraska:*** *from* Ground Water, May-June 1979, Vol. 17, No. 3: J.R. Gormly and R.F. Spalding - $1.50 (RS-26)

—***Chemical Seepage From a Tail Water Recovery Pit to Adjacent Ground Water:*** *from* Journal of Environmental Quality, July-September 1979, Vol. 8, No. 3: R.F. Spalding, M.E. Exner (Spalding), J.J. Sullivan and P.A. Lyon - $1.50 (RS-27)

—***Areal, Vertical, and Temporal Differences in Ground Water Chemistry:*** *from* Journal of Environmental Quality, July-September 1980, Vol. 9, No. 3: I. Inorganic Constituents—R.F. Spalding and M.E. Exner (Spalding); II. Organic Constituents— G.A. Junk, R.F. Spalding and J.J. Richard - $1.50 (RS-31)

—***Water—Pesticides in Ground Water Beneath Irrigated Farmland in Nebraska, August 1978:*** *from* Pesticides Monitoring Journal, September 1980, Vol. 14, No. 2: R.F. Spalding, G.A. Junk and J.J. Richard - $1.50 (RS-33)

(Cont. from p. 39)

—Major Procedural Discrepancies in Soil Extracted Nitrate Levels and Nitrogen Isotopic Values: *from* Ground Water, May-June 1984, Vol. 22, No. 3: C.W. Lindau and R.F. Spalding - $1.50 (RS-44)

—Ground-Water Contamination and Well Construction in Southeast Nebraska: *from* Ground Water, January-February 1985, Vol. 23, No. 1: M.E. Exner (Spalding), C.W. Lindau and R.F. Spalding - $1.50 (RS-46)

—VOCs (Volatile Organic Compounds) in Ground Water Influenced by Large Scale Withdrawals: *from* Ground Water, July-August 1987, Vol. 25, No. 4: A.J. Fischer, E.A. Rowan, and R.F. Spalding - $1.50 (RS-65)

—Hydrostratigraphy and Distribution of Secondary Permeability in the Brule Formation, Cheyenne County, Nebraska: *from* Geological Society of America Bulletin, October 1987, Vol. 99: Warren Barrash and R. H. Morin - $1.50 (RS-67)

—Defining Patterns of Ground Water and Heat Flow in Fractured Brule Formation, Western Nebraska, Using Borehole Geophysical Methods: *from* proceedings of the Surface and Borehole Geophysical Methods and Ground Water Instrumentation Conference and Exposition: R.H. Morin and Warren Barrash - $1.50 (RS-68)

—Decade of North American Geology Field Guides for Nebraska: *from* The Decade of North American Geology Field Guides, *The Geology of North America:* Nebraska Geological Survey, Department of Geology and Nebraska State Museum, University of Nebraska-Lincoln (1987) - $2.00 (RS-71)

—Groundwater Munition Residues and Nitrate near Grand Island, Nebraska, U.S.A.: *from* Journal of Contaminant Hydrology, No. 2, 1988: R.F. Spalding and J.W. Fulton - $1.50 (RS-72)

—Nitrate in the Intermediate Vadose Zone Beneath Irrigated Cropland: *from* Ground Water Monitoring Review, Spring, 1988: R.F. Spalding and L.A. Kitchen - $1.50 (RS-75)

Maps

—Geologic Bedrock Map of Nebraska, 1986: R. R. Burchett; color print (1:1,000,000) - $4.50 (GMC-1)

—Test Hole Location Map; revised, 1988 (1:500,000) - $3.50
(GM-12)

—Groundwater Nitrate-Nitrogen Concentrations, 1980: R.F. Spalding, project director; M.E. Exner, map and text: for Alliance, Broken Bow, Fremont, Grand Island, Lincoln and Scottsbluff - $2.50 each (GM-48)

—Nitrate-Nitrogen Concentration in Water from Sampled Wells and Sand Pits of Pierce County, 1981 (1:125,000) - $2.50 (GM-50)

—Configuration of Water Table, Spring 1979: after G.W. Freethey; printed on U.S. Geological Survey 1 degree x 2 degree base (1:250,000) - Available for various quadrangles of the state - $2.50 each (GM-54)

—Base of the Principal Aquifer, 1980; printed on U.S. Geological Survey 1 degree x 2 degree base (1.250,000) - Available for various quadrangles of the state - $2.50 each (GM-55)

—Thickness of Principal Aquifer, 1980; printed on U.S. Geological Survey 1 degree x 2 degree base (1:250,000) - Available for various quadrangles of the state - $2.50 each (GM-56)

—Concentration of Nitrate-Nitrogen in Groundwater, Central Platte Region, Nebraska, 1984 (1:500,000): M.E. Exner (Spalding) - $3.50 (GM-59)

—Center-Pivot Irrigation Systems in Nebraska, 1987: D.C. Rundquist, project leader; Allen Cook, project researcher; color print (1:1,000,000) - $2.50 (LUM-27)

—Nebraska Natural Resources District Boundaries (1:1,000,000) - Free (GRM-10)

—Vegetative Conditions in Nebraska, As Viewed by Satellite, 1988 Growing Season [shows area affected by 1988 drought], A.J. Peters and D.H. Greegor, Jr.; color print (eight image-maps; 1:2,500,000) - $2.50 (GRM-12)

Contract reports

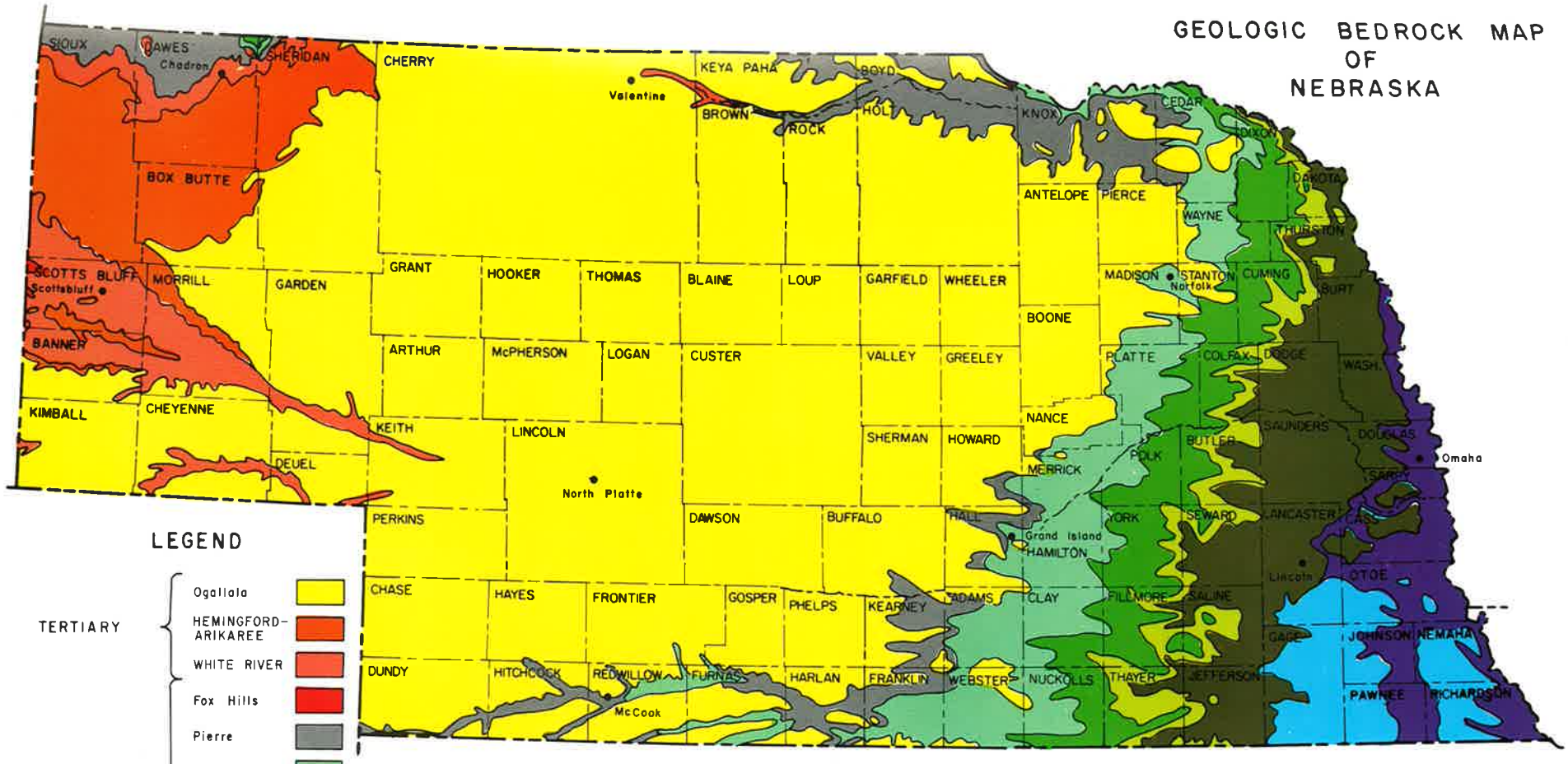
—A Manual on the Preparation of Special Groundwater Protection Area Action Plans: R.A. Kuzelka and others (1990) - Published by the Nebraska Department of Environmental Control and the Nebraska Association of Resources Districts - Available for study at CSD

—Bazile Triangle Groundwater Quality Study: D. C. Gosselin (1990) - Final report for Contract 89-2 for Nebraska Department of Environmental Control - Available for study at CSD (to be published as a Water Survey Paper in 1990)

Publications available elsewhere

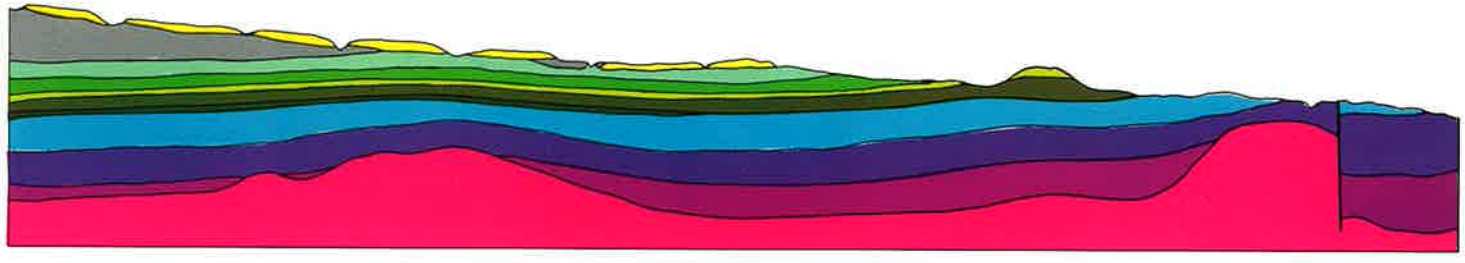
—Occurrence of Pesticides and Nitrate in Nebraska's Ground Water: M. E. Exner (Spalding) and R. F. Spalding (1990) - $5 - Available from the NU Water Center, Institute of Agriculture and Natural Resources

GEOLOGIC BEDROCK MAP OF NEBRASKA



LEGEND

- TERTIARY
  - Ogallala
  - HEMINGFORD–ARIKAREE
  - WHITE RIVER
- CRETACEOUS
  - Fox Hills
  - Pierre
  - Niobrara
  - Carlile
  - Greenhorn–Graneros
  - DAKOTA
- JURASSIC
- PERMIAN
- PENNSYLVANIAN
- MISSISSIPPIAN, DEVONIAN, SILURIAN, ORDOVICIAN, CAMBRIAN
- PRECAMBRIAN



Cross Section Along Southern Nebraska Border

20 0 20 40 60
Scale in Miles

University of Nebraska
Conservation & Survey Division
Nebraska Geological Survey
1969

NOTE: Unconsolidated sediments of Pleistocene age cover the bedrock throughout much of the State and are not shown.

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